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Bringing Police Airwaves Inside Buildings: The Hong Kong Police Force's Pioneering Finance-Own-Operate-Share (FOOS) Public-Private Partnership Project

A Project Report Submitted to Middlesex University
In Partial Fulfilment of the Requirements for the Degree of
Doctor of Professional Studies

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Institute For Work Based Learning
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July 2014

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DEDICATIONS

This project report is dedicated:

1. Firstly, to my dearest wife Fontane and son Wilfred, both of whom have supported me steadfastly in the writing of it over the past several years, and

2. Secondly, to public safety first and subsequent responders, who all have a need for effective indoor communications in carrying out their supremely important, often heroic, duties in support of the communities that they serve.

ACKNOWLEDGEMENTS

It would be remiss of me not to acknowledge the following persons who have given me so much support and encouragement over a protracted period:

- Dr Carlye Tsui, my Project Advisor, for her meticulous guidance, useful advice and thoughtful care for all academic matters throughout my study

- Dr Brian To, my Project Consultant, for his insightful advice on the professional development of this work

- Prof. Steven G W Li, ProVice-Chancellor, and the staff of the Middlesex University East Asian Regional Office in Hong Kong for their caring support and encouragement

- Mr Andy Tsang Wai Hung, Commissioner of Police, Mr William Tang Hou Kwong, Senior Assistant Commissioner of Police, Mr. Peter G Else, Assistant Commissioner of Police and Mr Stephen Cheng See Lim, Director of the Police College – all of the Hong Kong Police Force - for their full support and permission to conduct academic research in relation to my work

- Prof. Philip Tsang, Vice-President, Web Consortium Education Foundation, Caritas Institute of Higher Education and Prof. Paul Kwok, Director, College of Full-time Studies, The Open University of Hong Kong, for their kind support and academic advice on the professional development of the research survey and questionnaires in connection with my study.

- Mr Lam Wai Hang, Force Librarian and Dr Lam Kam Yuen, Force Curator, Hong Kong Police Force for their kind assistance in library and museum resources in connection with my study, and

- The staff engineers and technical staff of the Professional Mobile Radio Division of the Communications Branch, Hong Kong Police Force, especially Messrs Cheung Ho Ming, Senior Telecommunications Engineer and Kinson Lam, Telecommunications Engineer for their professionalism and leadership in piloting the FOOS (Finance-Own-Operate-Share) Model at Telford Plaza

The following persons and organisations, in alphabetical order, provided thoughtful and highly professional testimonials in relation to the project:

- Sir David Brown, Chairman of British Standards Institution (BSI) and Past President, The Institution of Engineering and Technology (IET)

- Dr David Callaghan, Technical Director, Radio Communications Products, Thales UK Ltd.

- Mr. Stephen Chau, Chief Technology Officer, SmarTone Mobile Communications Ltd., Hong Kong

- Ir W Y Chu, Senior Telecommunications Manager, CLP Power Company, Hong Kong

- Mr. Peter Goulding, Public Safety Specialist, Motorola Solutions Inc. and Former Chief Superintendent, Directorate of Information, London Metropolitan Police, UK

- Mr. Yung Kuen Ha, Deputy Director General (Telecommunications) Office of Communications Authority (OFCA) Hong Kong

- Dr Peter Halliday, CEO of Elite Consulting Company and Former Assistance Commissioner of the Hong Kong Police Force

- Professor Martin Henson, Dean for International Affairs, University of Essex, UK

- Mr. Jeppe Jepsen, Chairman, Spectrum Harmonisation, Public Safety Communications Europe and Vice Chairman TETRA and Critical Communications Association

- Mr. Phil Kidner, CEO of TETRA and Critical Communications Association

- Professor Jim Norton, Past President BCS, Chartered Institute for IT and Former Chief Executive, UK Radiocommunications Agency

- Mr. Francois Rancy, Director Radiocommunication Bureau, International Telecommunications Union (ITU)

- Mr. Duncan Swan, Partner Analysys Mason Ltd. UK, and

- Ms. Sandra Wendelken, Editor Radio Resource International Magazine, USA

GLOSSARY OF TERMS
(Arranged Alphabetically)

Term	Meaning
ADB	Asian Development Bank
ANOVA	Analysis of Variance (Statistics)
AVL	Automatic Vehicle (or Vessel) Location
3G	3rd Generation
3GPP	The 3rd Generation Partnership Project
4G LTE	4th Generation Long Term Evolution
BDA	Bi-Directional Amplifier
Beat Radio	The handheld radio issued to all patrolling officers
BLT	Build-Lease-Transfer
BOO	Build-Own-Operate
BOOT	Build-Own-Operate-Transfer
BOT	Build-Operate-Transfer
CAD	Computer-Aided Dispatch
CC1	HKPF's 1st Generation Command and Control System
CC2	HKPF's 2nd Generation Command and Control System
CC3	HKPF's 3rd Generation Command and Control System
DAS	Distributed Antenna System
dB	Decibel
dBm/W	Decibels per milliwatt
dBW	Decibels per watt
DBFO	Design-Build-Finance-Operate
DBOT	Design-Build-Operate-Transfer
DCMF	Design-Construct-Manage-Finance
DMO	Direct Mode Operation
ECACCS	(HKPF's) Enhanced Computer-Assisted Command and Control System
FOOS	Finance-Own-Operate-Share
GDP	Gross Domestic Product
GSM	Global System for Mobile Communications
HKPF	Hong Kong Police Force
HKSAR	Hong Kong Special Administrative Region
IET	Institution of Engineering and Technology
IRN	Integrated Radio Network
LMR	Land Mobile Radio
LSD	Least Significant Difference (Statistics)
LTE	Long Term Evolution
MTR	Mass Transit Railway
MTRC	Mass Transit Railway Corporation
OFCA	Office of the Communications Authority
One-Way ANOVA	One-Way Analysis of Variance (Statistics)
PCS	Personal Communications Service
PDA	Personal Digital Assistant
PFI	Private Finance Initiative
PPCP	Public-Private Community Partnership
PPP	Public-Private Partnership
PTT	Push-To-Talk
RES	Radio Enhancement System
RF	Radio Frequency

SPV	Special Purpose Vehicle
TETRA	Terrestrial Trunked Radio
UHF	Ultra High Frequency (300 MHz and 3 GHz)
VHF	Very High Frequency (30 MHz to 300 MHz)

ABSTRACT

It is the vision of the Hong Kong Police Force (HKPF) that the Hong Kong Special Administrative Region (HKSAR) remains one of the safest and most stable societies in the world.[1] The HKPF policing model which, *inter alia*, calls for a highly visible uniformed police presence – predominantly on foot - in places of public resort has proved to be effective in keeping crime and public disorder at low levels.[2]

An effective radio system facilitating communication between field officers, and between field officers and their command and control centres, is a prerequisite for effective modern policing. Whilst the intelligibility and reliability of outdoor police radio communications in the HKSAR is generally adequate, the same cannot be said of indoor coverage. Some 40 per cent of the HKSAR's population live above the 14th floor.[3] In addition, the HKSAR boasts a large number of shopping malls, car parks and other indoor public facilities. Deficiencies in indoor communications currently present a major operational challenge.

Technical solutions for indoor radio communications have been in place in various locations around for the world for some years and generally involve the emergency services deploying their own distributed antenna system (DAS)[4] or repeaters[5] inside buildings. Such solutions are generally expensive.

The project report addresses the concept of an alternative finance model involving HKPF 'plugging into' commercial telecommunications infrastructure at suitable and agreed connection points and hence sharing the in-building cabling and RF (Radio Frequency) radiating elements. HKPF uses dedicated radio spectrum. The project report proposes a Finance-Own-Operate-Share (FOOS) public-private partnership (PPP) approach. The project to produce a reference model is fully described from the original concept, through to the

[1] Hong Kong is rated No.9 of the top 100 safe cities according to the Safe City Index (Frost & Sullivan analysis, March 2012).
[2] Overall crime in Hong Kong in 2013 was 72,911 cases or 1,015 per 100,000 populations; that, for example, is about one tenth of the crime rate in London.
[3] Hong Kong Ecological Footprint Report 2008, World Wide Fund Hong Kong
[4] A distributed antenna system, or DAS, is a network of spatially separated antenna nodes connected to a common source via a transport medium that provides wireless service within a geographic area or structure. DAS antenna elevations are generally at or below the clutter level and node installations are compact.
[5] A repeater is an electronic device that receives a signal and retransmits it at a higher level or higher power, or onto the other side of an obstruction, so that the signal can cover longer distances.

selection of a partner, the design and implementation of a pilot scheme at a large HKSAR shopping mall, and user feedback. The project results have been validated by triangulation: firstly, by assessment of the technical results including user feedback; secondly, by a questionnaire survey of industry practitioners; and lastly, by testimonials from prominent figures in the telecommunications sphere.

The project has resulted in tangible and intangible benefits both for HKPF and the mobile phone companies concerned by way of substantial savings, improved quality of service and public goodwill. The reference model has potential worldwide application.

CHAPTER 1: INTRODUCTION

Radio has no future.

LORD KELVIN, BRITISH MATHEMATICIAN[6]

1.1 Introduction

Chapter 1 introduces the reader to the following:

1. Initial considerations
2. Proposed HKPF indoor radio communications improvement project
3. The Candidate
4. The Hong Kong Police Force (HKPF)
5. HKPF radio communications
6. Current status of HKPF indoor radio coverage, and
7. Methodology and results

1.2 Initial Considerations

Land mobile radios, whether used in vehicles or as handheld portables, are an important tool used every day by police officers to make their jobs safer and more efficient. For the most part, these radio systems function as designed, and serve the end-user with reliable communications. However, when the duties of police officers require them to enter a building, or operate below ground level during emergencies, the ability of their radios to communicate to the command and control centre or with each other may become an operational issue.

One physical constraint of land mobile radio communications is its inability to transmit and receive airwaves through obstructions such as buildings or underground structures. Indeed,

[6] http://zapatopi.net/kelvin/quotes/ (accessed 24 January 2014).

the failure of a land mobile radio to transmit and receive communications from within a building or below ground level has challenged radio users since the beginning of land mobile radio communications (Hashemi, 1993).

Faced with a public demanding ever-faster police response to incidents and crimes, the need for seamless radio coverage has evolved from a desirable to an essential requirement. HKPF needs clear and reliable radio communications for efficient incident management and enhanced officer safety.

Modern police radio communications in the HKSAR date back to 1977 and inadequate indoor coverage has invariably been a problem. In 1984, for example, an armed robbery occurred at the Landmark, a large and busy shopping mall in the Central Business District of the HKSAR. The alarm was raised whilst the robbery was in progress, and the police were quickly on the scene. Unfortunately, police beat radios did not function effectively inside the mall and as a result the police operation lacked coordination. The robbers shot their way out of the building and in the general confusion succeeded in getting the police to shoot at each other. By great good fortune, no members of the public or police officers were hurt. The police operation was accurately described at the time as a shambles. In the interests of public relations and at considerable expense, HKPF subsequently installed a repeater inside the mall. The missed golden opportunity to apprehend an extremely violent gang of criminals had serious repercussions in that the gang continued its activities for several years thereafter and killed several members of the public in the process (Gee, 2001).

Despite this 'wake up call,' there was no further substantive action to address indoor communications until the project described in this project report. There are, naturally, one or two specific exceptions to this, the Chek Lap Kok International Airport being one.

1.3 Proposed HKPF Indoor Radio Communications Improvement Project (the Improvement Project)

There were two aspects to the improvement project:

1. The technical model, and
2. The financing model

Of the technical options available, it was decided that 'simple' extension of existing HKPF's radio system to the interiors of buildings, by way of extending the infrastructure, was not viable, primarily because of the capital and maintenance costs involved. Accordingly, it was considered that collaboration with the private sector was the road ahead.

Private sector involvement has been woven into the Government's reform measures, mainly in the form of outsourcing and public-private partnerships (PPP) (Grimsby and Lewis, 2004). In the HKSAR, PPP continues to be encouraged within the public sector as a means to improve coverage, effectiveness, efficiency and quality in the delivery of public services (Efficiency Unit, 2008).

The take-up of PPP initiatives by public safety worldwide is currently patchy (Colverson, 2012). The City of Los Angeles has a formal programme of collaboration between the Los Angeles Police Department and private security companies and this appears, inter alia, to provide a level of flexibility not achieved in a conventional police-only model (IACP, 2004). In early 2000, in the United Kingdom, the former Police Information Technology Organisation (PITO) signed a framework arrangement with British Telecom for a new national radio service – Airwave - to be rolled out across police forces in England, Wales and Scotland under a Private Finance Initiative (PFI) (Corner, 2006). Nevertheless, the PPP philosophy has yet to achieve meaningful inroads into public safety.

In his RAL Level 8 (Recognition and Accreditation of Learning) Proposal,[7] the Candidate listed the following specific objectives of the project as follows:

1. A study of the background of police indoor radio communications systems technology
2. A review of mobile networks for public safety in buildings including a discussion on why indoor radio coverage is needed and how it is best implemented worldwide
3. A detailed investigation into indoor coverage solutions from basic directional antenna systems (DAS) through to advanced radio-over-fibre systems
4. The formulation of an effective public-private partnership model with which to implement the selected technical indoor communication solution
5. The documenting of a unique, single-source reference for practical knowledge behind

[7] For an explanation of the RAL process, see http://www.mdx.ac.uk/Assets/REGS-MDProfRegulations%20_3_16Feb2011Final.pdf (accessed 16 December 2013).

indoor radio planning based on real life examples and implemented systems and results by the HKPF

6. The development of a business-oriented reference model for PPP in the HKSAR Kong and how it might be adapted for use in and by other jurisdictions, and
7. A review of the politics of the industry and the transferability of the reference model

1.4 The Candidate

The Candidate is a graduate of the University of Essex (M.Sc. in Telecommunications and Information Systems) and the Chinese University of Hong Kong (M.Phil. in Digital Encryption). He is a career Hong Kong Special Administrative Region Government (HKSARG) civil servant with the HKPF and head of the Communications Branch in the rank of Chief Police Telecommunications Engineer. Amongst the major projects with which he has been associated is the development and implementation of HKPF's Third Generation Command and Control System (CC3), for which he was the chief systems architect. This new system went operational in 2006. A biodata of the Candidate is given at Appendix A.

In so far as CC3 uses the low power TETRA[8] technology standard and the specifications of the project did not call for comprehensive indoor communications coverage, such coverage was, initially, very limited. Following the roll-out of CC3 and especially user feedback, thought turned to how indoor coverage might be enhanced. After options reviews, it was decided to pursue a public-private partnership with the object of leveraging the indoor telecommunications infrastructure of the mobile phone operators to extend the CC3 coverage.

Following a successful pilot at a large shopping mall in Hong Kong, the Candidate determined to commit the project to paper in the form of a project report as part of the requirements of a doctoral degree in professional studies. The details of this are recorded in the Candidate's RAL 8.[9]

[8] Terrestrial Trunked Radio (TETRA) is an European Telecommunications Standards Institute (ETSI) standard for professional mobile radio designed for use by emergency services.

[9] Jolly Chun Kau WONG, Doctorate in Professional Studies, Planning a Practitioner Research Programme 4561, RAL 8 dated 6 January 2011

1.5 The Hong Kong Police Force (HKPF)

HKPF is one of the largest metropolitan police forces in the world; in size it rivals the Metropolitan Police Service of London, England and the New York Police Department in the United States.[10] Assets-wise, it is well provided with purpose-built community police stations, modern TETRA radio communications, computer-assisted command and control systems, computerised criminal records and intelligence systems, and other equipment (Wong, 2012).

On average, HKPF receives some 6,399 emergency ('999') calls daily.[11] HKPF pledges to respond to all genuine emergency calls within nine minutes in urban and 15 minutes in rural areas, be they in- or outdoors.[12]

The rates of crime and public disorder in the HKSAR are regarded as very low – one tenth of those in London,[13] for example. In 2013, a total of 72,911 crimes were recorded, representing a crime rate of 1,015 cases per 100,000 populations. Most categories of crime recorded a slight drop over 2012, the exceptions being deception, rape and indecent assault, pickpocketing, miscellaneous theft and criminal damage. Almost all crimes can take place either in- or outdoors. In addition to crime, there were around 5,100 public meetings in 2013.[14] Many of these take place indoors, particularly in inclement weather.

It would be as well to dispose of one, possibly contentious, issue from the outset and that is the legal position with regard to HKPF officers entering premises. The reader might reasonably ask why police officers are needed to enter what are essentially private premises, commonly patrolled by watchmen and security staff? In a nutshell, the duties of HKPF are ordained by Section 10 of the Police Force Ordinance, Cap. 232, which mandates a police response to all crime and disorder wherever it may occur. Whilst privately employed security staff can very possibly deal with minor incidents, HKPF must be involved where any sort of judicial proceeding may eventuate and such is the case most of the time.

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[10] HKPF has an establishment (as at 2012-12-31) of 28,392 sworn officers supported by 4,695 civilian officers.
[11] In 2013, the Police Regional Command and Control Centres received 2,313,816 calls. Around 80 per cent of these were for non-emergencies, or otherwise, frivolous, but all have to be answered.
[12] http://www.police.gov.Hong Kong/ppp_en/01_about_us/pp.html (accessed 18 June 2013).
[13] http://www.met.police.uk/crimefigures/ (accessed 18 June 2013).
[14] Line-to-take on Public Order Events, Operations Wing, HKPF, July 2014.

1.6 HKPF Radio Communications

In the HKSAR, the introduction of two-way radios to foot patrol police officers in the 1970s had a revolutionary effect on 'beat policing.'[15]

Though very basic in comparison with the current system, HKPF's First Generation Command and Control Communications System (CC1), introduced in 1977, was an advanced system at the time. The HKSAR was one of the first cities in the world, for example, to place the extension speaker-microphone conveniently on an officer's shoulder strap, providing much easier and faster hands-free communications. The defining move forward, however, was the creation of regional command and control centres, allowing field officers to be directed and supported from a central coordinating point.

The Second Generation Command and Control Communications System (CC2) was introduced in 1990. Radio communications and computer applications merged together so that CC2 could link to a variety of specialist services that enabled and enhanced operational, investigative and intelligence capabilities. CC2 comprised an integrated radio communications system (commonly known as the 'Beat Radio System'); the 999 Emergency Services Telephone Sub-system; and the Enhanced Computer Assisted Command and Control System (ECACCS). CC2 proved effective but reached the end of its useful life in 2004.

HKPF rolled out its Third Generation Command and Control Communications System (CC3) in March 2006 (Wong and Tsang, 2010). CC3 was designed and developed to meet the challenges of a fast changing environment and advancing technology, as well as the ever-increasing public expectation for more sophisticated police services and faster emergency response. It is axiomatic that public safety agencies require communications that are reliable, rapid, responsive and rugged (Killen, Stittleburg, Webb and Siamicki, 2005). For the initial rollout, the design scope focussed on effective outdoor radio communications.

[15] A foot patrol officer is responsible for patrolling a designated geographical area known as a 'beat.'

CC3 is operated under six regional command and control centres which direct police operations on the ground through radio communication with patrolling officers, and officers in vehicles and on board launches.

1.7 Current Status of HKPF Indoor Radio Coverage

With a land mass of 1,104 square kilometres and a population of over seven million people, the HKSAR is one of the most densely populated conurbations in the world. According to the *Guinness Book of Records 2012*, the Mong Kok District in Kowloon has the highest population density (130,000 per square kilometre) of any area on earth.

A strong economy and burgeoning population have resulted in an insatiable demand for new construction for both commercial and residential use, which has made the HKSAR one of the world's most 'vertical cities' (Wong, 2011). A full 40 per cent of the population lives on or above the 14th floor of residential buildings. Shopping malls have blossomed, generally sited underneath commercial and residential complexes. Indoor and underground car parks have also proliferated.

The police requires intelligible and reliable radio communication for effective incident management and officer safety. Seamless radio coverage, in particular indoor coverage has invariably been a challenge (Infonetics Research, 2007; Rappaport, 2002) to mobile radio systems. Police radio communications are no exception. Beat officers patrol inside buildings to combat burglary, robbery, shop thefts, criminal damage, pick-pocketing, and others, and at crime black spots in locations such as shopping malls, basement levels, inter/intra buildings tunnels and car parks. Patrol officers are expected to prevent and detect crime within their assigned patrol areas and beat radios are their primary means of requesting assistance from police command and control centres, and communicating with each other.

The design specification for CC3 stipulated, *inter alia*, that the system need support communications no further than one metre inside buildings (De Toledo, Turkmani and Parsons, 1998). It follows that, unless specifically provided for by way of repeaters[16] or bi-

[16] Special portable repeaters are available for ad hoc, planned operations.

directional[17] antenna, police communication inside buildings in the HKSAR cannot be relied upon.

By contrast, the mobile phone operators in the HKSAR have all developed comprehensive networks covering both outdoor and indoor communications. These operators, being commercial enterprises, have invested heavily in mobile phone infrastructure, intending to reap the rewards of such investment by establishing reputations for reliable mobile phone services and hence increasing numbers of (satisfied) customers. The only current method whereby police officers inside buildings can reliably communicate with each other and with their command and control centres is by the use of mobile phones. The carrying of two communication devices, however, is unsatisfactory from both the weight and bulk perspectives, and also because command and control centres cannot monitor operational mobile phone communications.

1.8 Methodology and Results

Starting in 2009 with a pilot scheme in a major shopping mall in the HKSAR and utilising the bidirectional amplifier and cabling infrastructure of one mobile phone operator (selected by an open tender), HKPF has now embarked upon a programme of extending CC3 coverage to inside buildings, by way of PPPs. 60 locations – mostly shopping malls – have been identified and the programme is due for completion by mid-2014.

Indoor communications at the selected locations now match mobile phone coverage. There have been major cost savings and frontline user feedback has been positive.

The reader is now invited to take a voyage of discovery into the world of indoor radio communications as conceived by and being implemented within HKPF.

[17] A bi-directional antenna (BDA) is a device used for boosting the radio reception to the local area by the usage of a reception antenna, a signal amplifier and an internal rebroadcast antenna. These are similar to the cellular broadcast towers used for broadcasting by the network providers, but are much smaller, usually intended for use in one building.

CHAPTER 2: TERMS OF REFERENCE

You are to infiltrate into the underworld and establish and maintain contacts with anyone who can give information which will lead to the arrests of criminals. You must stay in the background but you must get the information and plenty of it….Remember that the whole success of the plan depends on strict secrecy. You will have complete freedom of movement….You will not be asked any questions about the source of any information you may discover.

TERMS OF REFERENCE OF THE
NEWLY FORMED GHOST SQUAD,
LONDON, 31 DECEMBER 1945[18]

2.1 Introduction

This chapter describes the project charter and objectives.

2.2 Terms of Reference

Terms of reference (TORs) are used to describe the purpose, roles and structures of projects, working groups, reference groups and committees. They are guidelines for the way an individual will work – as in the case of this project report – or how group members will work with each other, and deciding the TORs is usually the first task undertaken by an individual/group. TORs provide a written basis for making decisions.

After due consideration, the TORs for the HKPF indoor radio communications enhancement project were identified to be:

[18] Gosling, J. (1959) *The Ghost Squad*, White Lion Publishers, London, pp.14-15.

1. Review the business case for improving police communications inside buildings in the HKSAR
2. Review technical models adopted in other parts of the world and their relevancy to HKPF and the HKSAR
3. Review finance models to fund the pilot
4. Conduct a pilot of the proposed technical solution at one location in the HKSAR
5. Assess the results of the pilot, and
6. Decide upon a reference model to fund the extending of the technical solution to other selected locations in the HKSAR

2.3 Objective

The overarching objective of the project was to develop an effective and affordable solution for HKPF to bring its airwaves into buildings. The objective accords with HKPF's Strategic Direction No. 4: *supporting frontline units*.[19] Professional mobile radio services will empower frontline units – particularly patrol sub-units and criminal investigation teams - with highly responsive and resilient communications capabilities to meet increasing safety and security needs, and will enable them to respond to calls for police services in a professional and confident manner.

The project was implemented by pilot testing the technical solution and then developing a PPP finance model designed particularly for public safety agencies (HKPF in this case) to extend the model to 59 other selected locations (making a total of 60 locations). These locations were selected according to a set of stringent criteria[20] designed to identify those where effective indoor communications is considered essential. The model was validated by triangulation in the form of: evaluating the field implementation; a survey of practitioners worldwide; and testimonials by experts and prominent leaders in the communications sphere.

---

[19] HKPF's four current (2013) Strategic Directions are as follows:
1. engaging the community
2. enhancing personal and professional qualities of HKPF members
3. strengthening criminal intelligence gathering Force-wide, and
4. supporting front-line units

[20] The criteria included:
- number of police order events
- crime reports
- pedestrian average and peak
- high risk premises

2.4 Project Statement

Defining the TORs and Objectives resulted in the development of the following project statement:

> *The development and implementation of a solution to significantly improve police indoor communications by partnering with the private sector will be a win for both parties; enhanced quality of police service on the one hand, and an important contribution to public service by the private sector, on the other.*

2.5 Logic Model

A logic model (also known as a logical framework, theory of change, or programme matrix) is a tool often used by managers and evaluators to evaluate the effectiveness of a programme or project. Logic models are usually a graphical depiction of the logical relationships between the resources, activities, outputs and outcomes of a programme.[21] Whilst there are many ways in which logic models can be presented, the underlying purpose of constructing one is to assess the 'if-then,' i.e. causal, relationships between the elements of the programme; if the resources are available for a programme, then the activities can be implemented; if the activities are implemented successfully then certain outputs and outcomes can be expected. Logic models are most often used in the evaluation stage of a programme but can also be used during planning and implementation.[22]

[21] http://www.uiweb.uidaho.edu/extension/LogicModel.pdf (accessed 26 July 2013).
[22] http://www.innonet.org/client_docs/File/logic_model_workbook.pdf (accessed 26 July 2013).

In its simplest form, a logic model has four components (W.K. Kellogg Foundation, 2004). Let us examine these using a straightforward programme as an example; a police programme to reduce crime in a large public park:

Inputs	Activities	Outputs	Outcomes/Impacts
What resources go into a programme	What activities the programme undertakes	What is produced through these activities	Benefits that result from the programme
Programme: Reduction of Crime in a Large Public Park			
1. Police manpower 2. Dogs 3. Vehicles 4. Informers 5. Matériel 6. Media 7. Finance (fees for informers, etc.)	1. Patrols 2. Special operations 3. Covert operations 4. Intelligence gathering 5. Publicity campaigns 6. Crime prevention campaigns	1. No. of patrols 2. No. of special operations 3. No. of covert operations 4. No. of pieces of intelligence gathered 5. No. of arrests 6. No. of prosecutions 7. No. of convictions	1. Increased use of park by the public 2. Heightened police credibility 3. Impetus to improve park's ambience and its facilities 4. Greater inclination by (and justification for) relevant bodies to increase police funding

Table 1: Simple Logic Model

Following early development of the logic model in the 1970s, a number of refinements and variations have been added to the basic concept. Many versions of logic models set out a series of outcomes/impacts, explaining in more detail the logic of how an intervention contributes to intended or observed results. This will often include distinguishing between short-term, medium-term and long-term results, and between direct and indirect results (Weiss, 1972).

In concluding this chapter, let us pull the various strands into a comprehensive logic model for our indoor communications initiative. This will serve as a template for the remainder of the project report and also a solid benchmark against which to judge the success or otherwise of the project.

2.6 HKPF Indoor Radio Communications Project

PROBLEM STATEMENT

Police telecommunications inside buildings and other indoor places of public resort are inadequate, which is having a negative impact on efficiency and effectiveness.

GOAL

To improve the aforesaid telecommunications to a level matching those of the mobile phone operators, such being now the *de facto* standard in the HKSAR.

LOGIC MODEL OF HKPF INDOOR COMMUNICATIONS PROJECT

A logic model of the project appears at Figure 1.

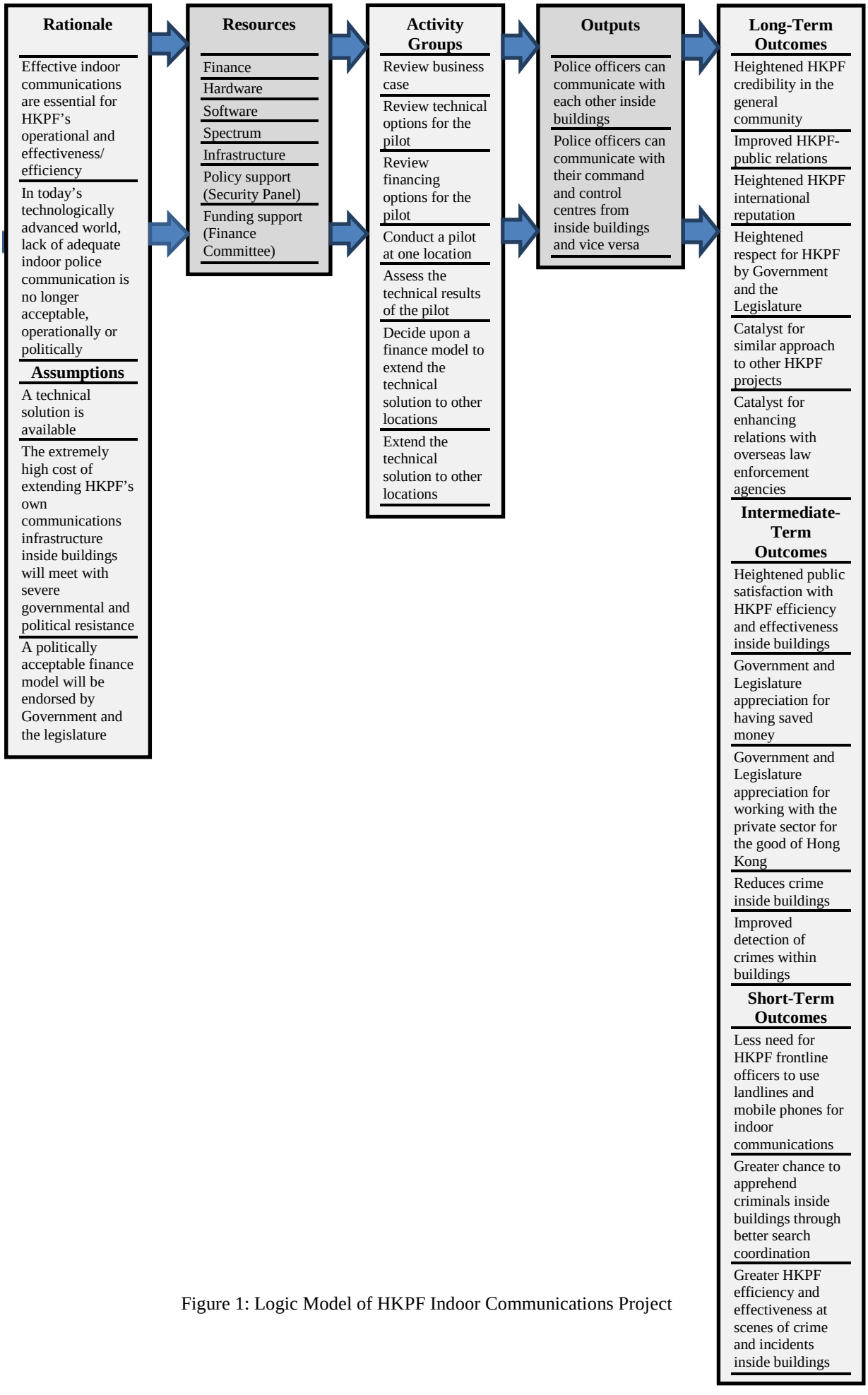

Figure 1: Logic Model of HKPF Indoor Communications Project

It will be seen that a clear distinction has been drawn between outputs and outcomes. Whilst improved indoor communication was obviously the objective, it is the outcomes that justify the project. Chapter 7 documents the strategic outcomes of the project.

CHAPTER 3: LITERATURE REVIEW

The average Ph.D. thesis is nothing but the transference of bones from one graveyard to another.

J. FRANK DOBIE[23]

3.1 Introduction

This chapter reviews the literature, worldwide, on:

1. Technical models to improve emergency services indoor communications, and
2. Finance models to fund such projects

A literature review is a text written by, typically, a researcher to consider the critical points of current knowledge including substantive findings, as well as theoretical and methodological contributions to a particular topic. Literature reviews are secondary sources, and as such, do not report any new or original experimental work. Also, a literature review can be interpreted as a review of an abstract accomplishment.

Most often associated with academic-orientateed literature, such as a thesis, a literature review usually precedes a research proposal and results section. Its main goals are to situate the current study within the body of literature and to provide context for the particular reader (Cooper, 1998).

3.2 Initial Considerations

Many public safety agencies believe that it is fair and reasonable to make a building developer or owner responsible for assuring a viable public safety radio signal throughout his

[23] Dobie, J.F. (1944) *A Texan in England*, Little Brown and Company, Boston.

or her property. This is particularly true when the building itself greatly attenuates[24] public safety airwaves, plus activities inside the building warrant a potential need for public safety response to the site. Some municipalities in the United States and Europe have written building or fire codes to address the problem.[25] The building developer or owner is required to comply with such codes before a certificate of occupancy is issued. However, results are often undesirable because codes are usually written in a language that is neither measurable nor enforceable, or the problem is seemingly insurmountable because of the huge number of legacy buildings in metropolitan cities. The alternative is, therefore, to place the burden of adequate radio coverage on the community as a whole, or to settle for situations where public safety radio communications are not reliable.

There are strong arguments for and against public safety agencies investing public money to fund in-building communications. Even where money might be available, metropolitan cities such as the HKSAR, New York, London, Shanghai and Tokyo, have a legacy of old buildings coupled with an increasingly urbanised structure. In such environments, extending radio coverage inside buildings poses serious financial and technical challenges.

3.3 Radio Communications Inside Buildings

Whilst a detailed discussion of the technical problems associated with radio communications inside buildings is not central to this project report, the problems are, nevertheless, germane to devising the finance model and should therefore be suitably addressed.

For several decades now, public safety agencies worldwide have relied on wireless communications to coordinate day-to-day and emergency operations. Their operating environment essentially requires a push-to-talk (PTT) mission-critical voice over wide-area

[24] Gradual loss of intensity of the signal. In electrical engineering and telecommunications, attenuation affects the propagation of waves and signals in electrical circuits, in optical fibres, as well as in air (airwaves).
[25] So does the Hong Kong SAR; the Office of the Communications Authority (OFCA) has issued two codes of practice: (1) Code of Practice for the Provision of Access Facilities in Buildings for the Supply of Telecommunications and Broadcasting Services (April 2012) at http://www.coms-auth.hk/filemanager/statement/en/upload/104/cop201201e.pdf (accessed 24 January 2014); and (2) Code of Practice for the Installation and Maintenance of In-Building Telecommunications Systems and In-building Access by Telecommunications Network Operators (April 2012) at http://www.coms-auth.hk/filemanager/statement/en/upload/105/cop201202e.pdf (accessed 24 January 2014).

land mobile radio (LMR)[26] network tailored to support the unique requirements of public safety and disaster recovery agencies such as law enforcement, ambulance services, civil emergency management, disaster relief, fire brigades, coast guard services, massive search and rescue, government administration and others (Salkintzis, 2006; DaSilva, Morgan, Bostian, Sweenly, Midkiff, Reed, Thompson, Newhall and Woerner, 2006).

The generally decentralised and autonomous nature of the various public safety agencies has led to the deployment of a variety of private LMR systems[27], primarily on voice communications and low-speed data transfer, operating in a fragmented radio spectrum (Doumi, 2006), ranging from lower VHF (very high frequency) to upper UHF (ultra high frequency) wavebands. Although developments such as digital trunking standards; access to wireless data; automatic vehicle or vessel location (AVL); and computer-aided dispatch (CAD), have been adopted to improve the performance of LMR systems, the radio coverage and traffic capacity of public safety radio communication systems have generally lagged behind that of commercial cellular systems.[28]

This disparity in coverage and capacity performance was not fully appreciated until a number of momentous incidents over the last decade including the destruction of the World Trade Center in 2001; the Indian Ocean earthquake and tsunami in 2004; the London bombings in 2005; and Hurricane Katrina in the Caribbean and the Gulf of Mexico, also in 2005. These disasters confirmed that radio coverage and capacity, both in- and outdoor, are of vital importance to emergency response departments in carrying out coordinated operations on a broad scale and in real time.

3.4 The Commercial Cellular Sector in the HKSAR

By contrast, the commercial cellular sector, both overseas and in the HKSAR, using 3G (3rd Generation) and 4G LTE (4th Generation Long Term Evolution) technologies, now offers a huge portfolio of services including voice, messaging, email, web browsing, picture transfer

[26] The term public safety land mobile radio (LMR) refers to wireless systems used by public safety agencies for coordinating teams and providing rapid emergency response.
[27] Project 25 and Terrestrial Trunked Radio (TETRA) are standardisation efforts that address LMR technologies by APCO (Association of Public Safety Communications Officials - International) in the U.S. and ETSI (European Telecommunications Standards Institute) in Europe respectively.
[28] http://gcn.com/articles/2013/08/15/san-luis-obispo-county-first-responders.aspx (accessed 13 December 2013).

and video streaming, and opens up a range of new capabilities to the next generation of public safety agencies. In spite of the challenges for network security and integrity, 4G LTE has the capability to revolutionise how first responders operate during emergencies.

The HKSAR has five mobile cellular phone operators. The number of public mobile subscribers has more than doubled over the past decade, reaching 17.07 million[29] in November 2013. The number of public mobile subscribers per 100 population was 235 (that is to say, the number of mobile telephone numbers issued – many people have more than one mobile phone at the same point in time), making the HKSAR one of the densest users of mobile phones in the world. There are some 6,000 cell sites per operator on average around the HKSAR, which has an area of just 1,104 square kilometres. Mobile operators in the HKSAR have invested a large amount of time and money in building their network infrastructures, including inside buildings. In November 2013, there were some 11.69 million[30] subscribers of 3G and 4G mobile phone services, showing an average increase of 50 per cent per annum during the past five years. The maturity of the mobile industry in the HKSAR makes a strong case for the public and private sectors collaborating – certainly in terms of networks – in providing wireless emergency communications. Let us now look at the public sector agency with which we are concerned; the Hong Kong Police Force.

3.5 The Hong Kong Policing Model: Indoor Policing

Across the globe, community policing has been the most important development in policing in the past quarter decade including the HKSAR (Skogan, 2004). The community policing model supplements traditional crime-fighting with a problem-solving and prevention-oriented approach that emphasises the role of the public and the interaction between police officers and the public.

Community policing initiatives may differ from place to place. In the HKSAR, an academic view is that community policing has been through seven stages of development since the late 1960s (Cheuk, 1999, pp.165-166; Lo and Cheuk, 2003, pp.102-104). Community policing was thought to be an effective answer to the deterioration of public order and the decline in

[29] *Key Statistics for Telecommunications in Hong Kong* published by the Office of the Communications Authority (29 January 2014).
[30] Ibid.

public trust in the 1960s in order to improve police-public relations, rebuild popular trust in the police and mobilise support for crime control. In the *Hong Kong Police Strategic Directions and Strategic Action Plans 2008-2010* and *2011-2013*, the emphasis has been on community-oriented policing where the strategic vision of community engagement is to enhance understanding and confidence of the public and earn their support and cooperation. High police visibility at street level and in places of public resort is considered vital to enhance interaction with the community.

In the HKSAR, patrol officers are expected to familiarise themselves with their beat patrol areas and local problems, particularly crime trends, crime black spots, personalities, nuisance and traffic problems. In addition to beat patrols at street level, field officers regularly perform patrols in multi-storey buildings, shopping malls, indoor car parks, stadia and other enclosed premises. Adequate and seamless indoor and in-building police radio coverage is essential in this respect.

3.6 Indoor Radio Communications Requirements and Challenges

The extent of radio coverage is largely determined by transmitted power and receiver sensitivity, combined with the propagation characteristics of the radio frequency being used (Gray, 2003). LMR users usually have less choice as to where to make a call than a cellular phone user. The call location is often dictated by the operational purpose or stipulated by the location of the user workplace. In the case of public safety agencies, constraints can be even more severe. For example, a mountain rescue service may require coverage in areas where public cellular systems are not provided, but even in more benign indoor radio environments, the absence of black spots is also very important.

3.7 Existing Models for Indoor Communications

Worldwide, local civil defence and first responder agencies, including fire jurisdictions and police authorities, have adopted standards[31] for in-building public safety radio enhancement systems (RES). These standards have been developed to ensure adequate indoor radio

[31] Section 510 of the International Fire Code (IFC), International Building Code, National Fire Protection Association (NFPA) Fire Code, and Recommendation 22 of the National Institute of Standards and Technology (NIST) are common industry standards.

coverage for fire fighters and police officers for emergency response. RES is better known in the industry as a Distributed Antenna System (DAS) and is the conventional solution to address the indoor radio coverage problem. DAS is a network of components that distributes radio signals throughout the building from a central point. The system takes airwaves and then amplifies and distributes them, using an off-air bi-directional amplifier (BDA) connected to an outside antenna which points to a donor site and a cabling structure (NPSTC, 2007a; NPSTC, 2007b).[32] The BDA subsequently transmits the waves through remote antennas to provide adequate radio coverage. DAS provides a solution to improve in-building radio coverage for anyone using a mobile phone, police radio, or a wireless laptop (Saleh, Rustaks and Roman, 1987). Such a traditional design of repeater systems, with distributed antennas or radiating coaxial feeders can obtain seamless internal radio coverage. Nevertheless, a DAS model carries a high installation cost and involves a long implementation period.

Figure 2 shows the architecture of a typical DAS to enable indoor communication within a shopping arcade; Telford Plaza in Kowloon Bay, HKSAR.

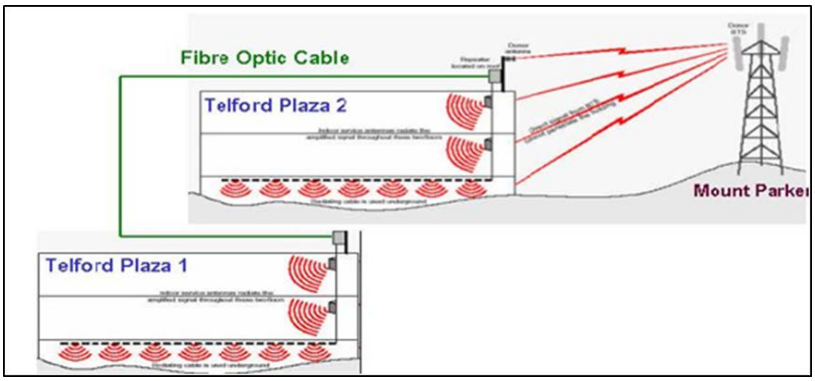

Figure 2: Distributed Antenna System (DAS) as Applied in Telford Plaza
(Source: Candidate's Work)

In the HKSAR, HKPF Emergency Unit vehicles are usually the first to respond to most significant incidents (Bernett, 2010). A quick, temporary solution to in-building coverage can be that the arriving police unit deploys a portable or transportable repeater to extend the range of police communications (Gray, 2003). Although this solution is not perfect, it has the

[32] The cabling structure is normally made of coaxial cable or fibre optic (radio-over-fibre) depending on the length.

obvious advantages of quick and easy set up, and can provide reasonable internal coverage during emergency situations.

Table 2 provides a consolidated breakdown of technical options for mitigating indoor radio communications problems.

3.8 Technical Options

	Model	Advantages	Disadvantages	Suitability for HKPF Indoor Communications Project
1	Build Own Infrastructure	Ownership	1. Cost 2. Maintenance costs 3. No economies of scale	Suitable depending upon cost
2	Portable repeaters	Ownership Relatively low cost	4. Reliability 5. Availability	Suitable in some circumstances
3	Share Infrastructure with Commercial Entity	1. Minimal investment 2. Minimal maintenance costs 3. No 'future proofing'	1. Security 2. 'Locked in' to one commercial operator 3. Exit barriers	Suitable

Table 2: Technical Options for Indoor Radio Communications

These options were critically reviewed by the project team. Option 2 affords only a temporary solution. Options 1 and 3 offer effective technical solutions which moves the argument forwards towards affordability. In this view, Option 3 has a decided edge, utilising as it does, existing infrastructure. Accordingly, the decision was made to adopt Option 3.

3.9 Finance Model

The first consideration was whether to adopt the traditional approach of an 'in-house' model, i.e. HKPF designs the system and then either installs it using police personnel or tenders for a contractor to do the work under police supervision. In this scenario, HKPF pays all the costs. The other option was for some form of public-private sector collaboration, involving shared costs and risk.

At Appendix B is a copy of a paper prepared at the outset of the indoor communications project to obtain an accurate estimate of costs using the traditional approach.[33] It will be seen that capital and recurrent expenditure were estimated at HK$94.2 million and HK$8.5 million, respectively. These are substantial sums and it was the Candidate's judgement at the time, coupled with discussions with his superiors, that obtaining funding of this magnitude would be an arduous if not ultimately fruitless process. It was envisaged that a question that would be asked early on in the funding process would be: What are the options? This gave rise to protracted consideration as to what those other options might be.

It will be seen that paragraph 14 of Appendix B advances the option of sharing the infrastructure of the mobile phone operators inside buildings. Nevertheless, the overarching thrust of the paper was to lay down the implications of the traditional in-house (and in-house funding) approach.

On the assumption that the traditional approach is not favoured, the alternative is some form of collaboration with the private sector, leveraging its antennae and cabling infrastructure. This would reduce costs to HKPF and share the risk into the bargain. Expressed another way, a collaboration would achieve a politically attractive aim of cross fertilisation and synergy with the private sector, and leveraging what it has to offer.

Accordingly, the investigation pointed to explore some form of public-private collaboration.

3.10 The Public-Private Partnership Model

3.10.1 Standard Model of Public Procurement

It will be helpful to put this section in context by looking briefly at the so-called standard model. Let us use the development of HKPF's Third Generation Command and Control System (CC3) as an example. The Hong Kong SAR is a signatory to the Agreement on Government Procurement (GPA) under the auspices of the World Trade Organisation

[33] 'McKinsey Format' is a template used by the Hong Kong Government for papers of this nature.

(WTO), which it signed in 1996. Generally, the Agreement emphasises openness, transparency and non-discrimination.[34]

The procurement model adopted for CC3 is as follows. Except where otherwise indicated the work was undertaken by HKPF:

1. Worldwide research into latest technologies including the issue of a Request for Information (RFI)
2. Design and costing of the proposed system
3. Application for funding through the government apparatus
4. Capital and recurrent funding (from the public purse) secured
5. Worldwide tender issued
6. Tender closed
7. Bids evaluated and contract awarded
8. Successful vendor signs contract and then builds, installs and tests system. HKPF monitors. Contract contains various guarantees and liability clauses
9. System handed over to HKPF
10. Series of capital payments made to vendor
11. Vendor maintains system in accordance with maintenance contract for stipulated period of years. Contract contains various performance clauses. Periodic maintenance payments made. HKPF monitors

[34] http://www.wto.org/english/tratop_e/gproc_e/gp_gpa_e.htm (accessed 10 July 2014).

3.10.2 Outsourcing

Of relevance, also, is the use by government and, indeed, many private organisations of the stratagem of outsourcing, a term that became popular in the United States around the turn of the 21st century. In simple terms, this is a practice used by different organisations to reduce overhead by contracting portions of work to outside suppliers rather than undertaking it internally.[35]

Outsourcing is an effective cost-saving strategy when used properly. It is sometimes more affordable to purchase a good from companies with comparative advantages than it is to produce the good internally. An example of a manufacturing company outsourcing would be Dell buying some of its computer components from another manufacturer in order to save on production costs. Alternatively, businesses may decide to outsource bookkeeping duties to independent accounting firms, as it may be cheaper than retaining an in-house accountant.

Examples of outsourcing undertaken by HKPF include the provision of building security by a private security company instead of using police officers, and the provision of commercial cleaning services rather than using government staff. In most respects, also, the maintenance contract signed between HKPF and the vendor for the maintenance of CC3 also constitutes outsourcing.

As with all human endeavours, however, there are pitfalls and consequences with outsourcing, the over-arching one being that sometimes the organisation deciding to outsource does not entirely understand what it is that it is proposing to 'offload.' In turn, the organisation contracted to undertake the outsourced work does not appreciate the intricacies of what it has taken on. The consequences for both parties are self-evident.

3.10.3 Public-Private Partnership

As its name implies, a public-private partnership (PPP) is collaboration between the public and private sectors. The central idea is that the relative stability of a government agency

[35] http://www.investopedia.com/terms/o/outsourcing.asp (accessed 10 July 2014).

combines with the relative dynamism of a private company to produce a project or provide a service. (Barlow, Roehrich and Wright, 2013).

A PPP usually involves the private sector agency assuming significant financial risk and also accountability in the event that things go wrong. Sometimes the cost of using the service is charged in its entirety to the service users. Sometimes the private sector agency will fund the capital expenditure in accordance with a contract drawn up with the government agency concerned. The government agency will then assume the costs of providing the service (Barlow, Roehrich and Wright, 2013). This was the model adopted by the Airwave project in the U.K. Sometimes a transfer of assets from the public to private sectors may be involved (Zheng, Roehrich and Lewis, 2008; Moszoro and Gasiorowski, 2007).

3.10.4 Origins

The main driver for PPP was the spiralling levels of public debt in many countries in the 1970s and 1980s. The rhetoric of those times was that the private sector is 'more efficient,' 'more effective,' 'more responsive,' 'less bureaucratic,' 'cheaper' (and prosier still: 'more cost-effective') and so on, seemingly ad infinitum. As the financial meltdown in the first few years of the 21st century, involving many large, 'blue chip' companies, banks, lending institutions and other previously venerated organisations demonstrated, however, 'more avaricious and deceitful' would have been an entirely justifiable addition to the foregoing list. Self- and shareholder enrichment were the orders of the day, and the term 'government bail-out' entered the lexicon.

The infantile notion that the funding of infrastructure development by the private sector constituted a method of doing this 'for free' (to the public) has now been generally discredited,[36] however interest in alternatives to the standard model of public procurement has continued. It has been argued that models involving an enhanced role for the private sector, with a single private-sector organisation taking responsibility for most aspects of service provision for a given project, could yield an improved allocation of risk, while maintaining public sector accountability for essential aspects of service provision (Möric, 2009; Quiggin, 1996).

[36] Nevertheless, the FOOS PPP model described later in the project report does utilise privately funded infrastructure. HKPF paid the 'plug-in' costs.

Let us look at experience around the world.

Country	Forays into PPP
United Kingdom	Private Finance Initiative (PFI) introduced by the John Major Government in 1992. Intention was to reduce the Public Sector Borrowing Requirement but this objective largely failed. Tony Blair Government expanded the initiative and sought to balance risk between government and private sector more equitably, and emphasise greater 'value for money.' Many programmes overran their budgets and were cancelled at great cost.
Australia	State governments have embraced the PFI. A notable model is Partnerships Victoria. Programme is claimed to have been generally successful.
Canada	Canadian Council for Public-Private Partnerships established in 1993 (a member-sponsored organisation with representatives from both the public and the private sectors). National Awards Program to celebrate successful public-private programmes held in November.[37] Major infrastructure projects include transit systems, such as Viva (bus rapid transit) and Ontario Highway 407.
India	The Government of India defines PPP as: "…a partnership between a public sector entity (sponsoring authority) and a private sector entity (a legal entity in which 51% or more of equity is with the private partner/s) for the creation and/or management of infrastructure for public purpose for a specified period of time (concession period) on commercial terms and in which the private partner has been procured through a transparent and open procurement system."[38] The Government has estimated an investment of US$320 billion in the infrastructure in its 10th plan (Raju, 2011).

Table 3: Forays into PPP by Selected Countries

3.10.5 Take-up of Public-Private Partnerships

The impetus of PPP, as an initiative and in practice may be seen as a development of the new public management paradigm of the late 20th century and globalisation pressures (Hood, 1991). Unfortunately, the term 'public-private partnership' is susceptible to thinking in parts of rather than the totality of the partnership, which makes it difficult to agree on a universally accepted definition of PPP.

[37] http://www.pppcouncil.ca/ (accessed 4 July 2013).
[38] http://www.albrightstonebridge.com/pub_private_partnerships/ (accessed 4 July 2013).

Over the past two decades more than 1,400 PPP contracts have been signed in the European Union, representing a capital value of approximately €260 billion.[39] Nevertheless, since the onset of the financial crisis in 2008, estimates suggest that the number of PPP contracts signed has fallen more than 40 per cent[40] (Barlow, Roehrich and Wright, 2010).

3.10.6 Dissent

A major complaint with PPP projects is that private investors have obtained a rate of return higher than the government's bond rate, even though most or all of the income risk associated with a project is borne by the public sector (Barlow, Roehrich and Wright, 2010; Harris, 1996). The evidence appears to bear this out.

Australian studies of early initiatives to promote private investment in infrastructure concluded that, in most cases, the schemes being proposed were inferior to the standard model of public procurement based on competitively tendered construction of publicly owned assets (Economic Planning Advisory Commission [EPAC], 1995a, 1995b; House of Representatives Standing Committee on Communications Transport and Microeconomic Reform, 1997; Harris, 1996; Industry Commission 1996; Quiggin 1996).

One response to these negative findings was the development of formal procedures for the assessment of PPPs in which the focus was on 'value for money,' rather than reductions in debt. The underlying framework was one in which value for money was achieved by an appropriate allocation of risk. These assessment procedures were incorporated in the private finance initiative and its Australian counterparts from the late 1990s onwards (EPAC, 1995a; EPAC, 1995b).

In 2009, the New Zealand Treasury released a report on PPP schemes that concluded that "there is little reliable empirical evidence about the costs and benefits of PPPs" and that there

[39] http://www.bei.europa.eu/attachments/efs/efr_2010_v04_en.pdf (accessed 8 July 2013).
[40] http://www.ft.com/intl/cms/s/58156c2e-007b-11df-b50b-00144feabdc0,Authorised=false.html?_i_location=http%3A%2F%2Fwww.ft.com%2Fcms%2Fs%2F0%2F58156c2e-007b-11df-b50b-00144feabdc0.html&_i_referer=http%3A%2F%2Fen.wikipedia.org%2Fwiki%2FPublic_private_partnership#axzz2YQ0ZYX9h (accessed 8 July 2013).

"are other ways of obtaining private sector finance." Further, "the advantages of PPPs must be weighed against the contractual complexities and rigidities they entail."[41]

Interestingly, the New Zealand Treasury sees the decision to adopt a PPP rather than a standard model in the following terms:

- "Is the public agency able to specify outcomes in service level terms, thereby leaving scope for the PPP consortium to innovate and optimize?
- "Is it easy for the public agency to specify outcomes in a way that performance can be measured objectively and rewards and sanctions applied?
- "Are the public agency's desired outcomes likely to be durable, given the length of the contract?"[42]

The Candidate is impressed with the New Zealand PPP evaluation model and has utilised it in Chapter 7.

3.10.7 Specific Cases

When examining a subject as serious as PPP, it is always useful to look at specific cases to see what went well and what went less so. Reviewing specific cases is, of course, backward-looking, i.e. hindsight, but crystal ball analysis is even less reliable!

Country	Project	Notes
Australia	Airport Link,[43] the Cross City Tunnel,[44] and the Sydney Harbour Tunnel, [45] all in Sydney; the Southern Cross Station[46] redevelopment in Melbourne; and the Robina[47] Hospital in Queensland.	All projects suffered cost overruns and delays.
India	Road assets under the National Highways Authority of India[48] and Midday Meal	Regarded as having been very successful projects.

[41] http://www.treasury.govt.nz/publications/research-policy/ppp/2006/06-02 (accessed 6 August 2013) (no page numbers, see "Conclusions").
[42] Ibid, "Conclusions."
[43] http://www.smh.com.au/news/national/open-secrets/2005/10/30/1130607152241.html (accessed 8 July 2013).
[44] Ibid.
[45] http://www.drive.com.au/Editorial/ArticleDetail.aspx?ArticleID=59601&vf=1 (accessed 8 July 2013).
[46] http://www.theage.com.au/articles/2005/07/08/1120704557967.html (accessed 8 July 2013).
[47] http://www.health.qld.gov.au/robinahospital/ (accessed 8 July 2013).
[48] http://www.nhai.org/allphase.htm (accessed 9 July 2013).

	Scheme with Akshaya Patra Foundation.[49]	
Canada	PPP Canada Inc. created in 2009 as a Crown corporation with an independent Board of Directors reporting through the Minister of Finance to Parliament. British Columbia: Projects include Canada Line rapid transit line, Abbotsford[50] Hospital and Cancer Centre, Sea-to-Sky Highway project. Quebec: Number of notable PPPs including McGill University Health Centre[51], new western extension of Autoroute30, [52] Université de Montréal's Hospital Research Center.[53,54]	Most projects regarded as having been no more or less successful than those developed using standard model of procurement.
United Kingdom	London Underground; Ministry of Defence; Fazerkerley Prison; UK air traffic control	Two-thirds of London Underground PPP taken back under public control in July 2007 after four and a half years at estimated cost of £2 billion. Remaining one-third taken back under public control in May 2010 after seven and a half years, for a purchase price of £310 million. UK Government paid advisers £180 million for structuring, negotiating and implementing the PPP and reimbursed £275 million of bid costs to the winning bidders. 30 year PPP contract for refurbishment of Ministry of Defence Main Building in London estimated to have given saving of only £100,000 compared to the £746.2 million cost of public procurement. Refinancing of Fazerkerley Prison PFI contract following the completion of construction delivered 81 per cent gain to the private sector operator.

[49] http://www.akshayapatra.org/ (accessed 9 July 2013).
[50] http://www.fraserhealth.ca/about_us/building_for_better_health/abbotsford_regional_hospital_and_cancer_centre/ (accessed 9 July 2013).
[51] http://muhc.ca/ (accessed 9 July 2013).
[52] http://www.mtq.gouv.qc.ca/portal/page/portal/grands_projets/grands_projets_termines/parachevement_a30 (accessed 9 July 2013; in French).
[53] http://www.umontreal.ca/ (accessed 9 July 2013).
[54] http://pp.egc.ra.abc.s2iweb.com/crchum/le-crchum.en.html (accessed 9 July 2013).

		NATS Holdings PPP saw 51 per cent of the U.K.'s air traffic control service transferred to the private sector. Following decline in air traffic after terrorist attacks on World Trade Center of 11 September 2001, Government and BAA Limited each invested £65 million in private sector operator in 2003.

Table 4: Specific Examples of PPP Projects Worldwide

3.11 Formal PPP Definitions

PPPs have been deployed for many years to deliver infrastructure facilities and services in many countries. Academics, practitioners, governments and international organisations have developed a range of definitions of PPP, as summarised in Table 5.

Canada: The Canadian Council for Public-Private Partnerships	A cooperative venture between the public and private sectors, built on the expertise of each partner that best meets clearly defined public needs through the appropriate allocation of resources, risks and rewards.[55]
USA: The National Council for Public-Private Partnerships	A Public-Private Partnership (PPP) is a contractual agreement between a public agency (federal, state or local) and a private sector entity. Through this agreement, the skills and assets of each sector (public and private) are shared in delivering a service or facility for the use of the general public. In addition to the sharing of resources, each party shares in the risks and rewards potential in the delivery of the service and/or facility.[56]
Hong Kong: Efficiency Unit	Public-Private Partnerships (PPPs) are arrangements where the public and private sectors both bring their complementary skills to a project, with varying levels of involvement and responsibility, for the purpose of providing public services or projects.[57]
Kwak, Chih, and Ibbs (2009)	Partnership between public and private sectors, the two sectors work cooperatively towards shared objectives; and they share risks and responsibilities.
Stovall (2009)	PPPs are relationships that are built between public and private entities to enhance comprehensive hazard mitigation, preparedness, response, and recovery programmes in the community.[58]

[55] http://www.pppcouncil.ca/resources/about-ppp/definitions.html (accessed 9 July 2013).
[56] http://www.ncppp.org/howpart/index.shtml (accessed 9 July 2013).
[57] http://www.eu.gov.Hong Kong/english/psi/psi_ppp/psi_ppp_over/psi_ppp_over.html (accessed 9 July 2013).
[58] Cited in http://www.ip3.org/ip3_site/using-public-private-partnerships-to-enhance-emergency-management.html?print=1&tmpl=component (accessed 9 July 2013).

Table 5: Definitions of PPP

Despite the variations in PPP definition, there is general agreement that the core shared component of a PPP consists of a partnership between public and private sectors; the two sectors work cooperatively towards shared objectives; and they share risks and responsibilities (Kwak et al., 2009). In other words, the public sector will engage private sector providers to develop facilities and deliver services that the private sector can provide more effectively and efficiently. From a police service management standpoint, it is important for both sectors to have a consistent understanding of what PPPs are, and how critical they are to emergency and disaster prevention, mitigation, preparedness, response, and recovery efforts on a day-to-day basis (Stovall, 2009).

3.12 General Track Record of PPPs

A Standard and Poor's survey in 2005 (Standard and Poor's, 2005) indicated that 88 per cent of PPP projects were delivered on time and to budget; by contrast, only 30 per cent of comparable projects delivered in the traditional way were completed to the same standard. Furthermore, no U.K. PPPs rated by Standard and Poor's have so far defaulted. Globally, it is expected that the PPP concept will continue to spread around the world. Growth in the sector has previously been held back by deficiencies in the legal and institutional frameworks, but in many countries the frameworks are now being put in place to accommodate PPPs. [59]

The Efficiency Unit of the HKSAR Government acknowledges the importance of deploying PPPs. In its latest PPP guide (Efficiency Unit, 2008), it advises that there has been a tremendous growth internationally in the use of the PPP approach to deliver large scale, long term facilities and services for the community. More and more governments, in particular many in Asia, have come to appreciate the improvements in service quality and value for money that well prepared PPP projects can achieve. PPPs are now an established part of public procurement in advanced and developing countries alike.

It is generally believed that the PPP approach can incorporate the strengths of both the public and private sectors. The exact benefits brought by the PPP will vary, depending upon the type and nature of the partnership. Figure 3 shows the number of benefits attributed to PPPs as reported by various authors and government units.

[59] http://www.ibtta.org/files/PDFs/PPP%20Credit%20Survey%20S%26P.pdf (accessed 9 July 2013).

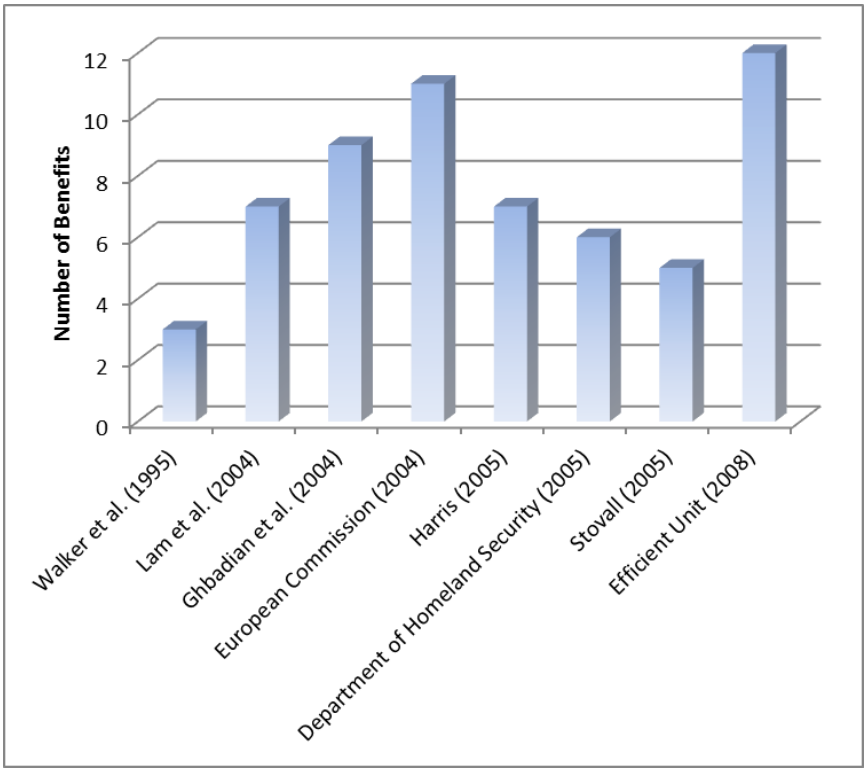

Figure 3: Number of Benefits in adopting PPPs

(Source: Candidate)

PPPs offer a number of advantages of exploitation by the public sector through the ability to raise additional finance in an environment of budgetary restriction, to make the best use of private sector operational efficiencies to reduce cost and increase quality to the public and the ability to speed up infrastructure development (European Commission, 2004).

Walker and Smith (1995), suggest a key reason for using a PPP is because the private sector normally possesses better mobility than the public sector. For example, the private sector is not only able to save the costs of project in planning, design, construction and operation, but also avoid the bureaucracy and relieve the administrative burden. The private sector can often provide better service to the public sector than *vice versa*, and establish a good partnership so that a balanced risk-return structure can be maintained. Some governments lack the ability to raise massive funds for large-scale infrastructure projects but private participation can mitigate a government's financial burden. Financial implications are particularly relevant to HKPF, as crime hot spots, for example, may alter over time. As such, investing heavily in permanent infrastructure by HKPF could be unreasonably costly and inflexible.

Three key benefits are commonly reported in the PPP literature: value for money; enhanced efficiency; and increased pace of infrastructure development (Lam et al, 2004; Harris, 2004; Vives 2006; Efficiency Unit, 2008; Kwak et al., 2009).

3.13 Types of PPP

Having reviewed the PPP experience worldwide, let us now examine particular types of PPP. This section discusses a number of PPP models.

3.13.1 Initial Considerations

A fundamental PPP model is a form of project financing. A private organisation receives a financial consideration from the private or public sector to finance, design, construct, and operate a facility stated in the partnership contract. This enables the private organisation concerned to recover its investment, and the operating and maintenance expenses expended on the project.

The World Bank offers an incisive visualisation of the various types of PPP agreements in the form of a spectrum ranging from limited private sector involvement to full divestment of the project, and all that that entails. Outsourcing, by definition, involves abrogation of any significant control over the project.

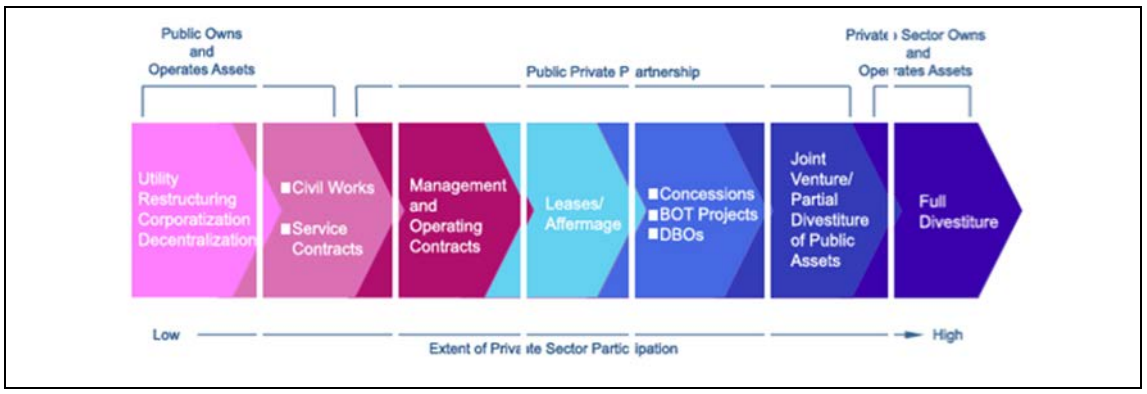

Figure 4: The World Bank PPP Continuum[60]

[60] http://ppp.worldbank.org/public-private-partnership/agreements (accessed 10 July 2014).

After due consideration of the options, the Candidate decided that a project finance plan based broadly on the BOT (Build-Operate-Transfer) approach, as above, offered the best chance of success in the sense of bringing police airwaves into buildings in the most cost-effective (and cost-conscious) and politically acceptable way.

Following is a review of the current types of PPP project finance.

#	Type	Nature	Notes
1	BOT (Build-Operate-Transfer)	Public body delegates to a private sector entity the design and building of infrastructure and the operation and maintenance of these facilities for a certain period. Private party has responsibility for raising the finance for the project and is entitled to retain all revenues generated by the project, and is the owner of the facility concerned. Facility is ultimately transferred to the public body at the end of the concession agreement[61] without any remuneration of the private party involved.	
2	BOOT (Build-Own-Operate-Transfer)	The private party owns the completed project. During the 'concession' period the private company owns and operates the facility with the prime goal being to recover the costs of investment and maintenance whilst at the same time endeavouring to improve its return on its investment.	Otherwise similar to BOT
3	BOO (Build–Own–Operate)	Ownership of project usually remains with the project company, for example a mobile phone network. Accordingly, private company gets benefits of any residual value of the project. BOO scheme typically involves large amounts of finance and long payback period.	Good example of BOO project is water treatment works. Raw water is pumped to the private water treatment works via public water mains. The water is treated and thereafter delivered to customers through the public network (Grimsey and Lewis, 2007).[62]
4	BLT (Build–Lease–Transfer)	Private entity builds complete project and leases it to government. Control over the project thus transferred from	

[61] http://ppp.worldbank.org/public-private-partnership/agreements/concessions-bots-dbos (accessed 10 July 2013).
[62] Not the same network that delivers the water to the treatment works!

		the project owner to a lessee, i.e. ownership remains with shareholders but operational functions of the project are leased. After the expiry of the lease period, the ownership of the asset and the operational responsibility are transferred to the government at a previously agreed price.	
5	DBFO (Design–Build–Finance–Operate)	Contractor assumes the risk of financing until the end of the contract period. The owner then assumes the responsibility for maintenance and operation. Model is extensively used in specific infrastructure projects such as toll roads. The private entity designs and constructs an item of infrastructure for the government, which is of course the true owner. Government receives periodic payments for the use of the infrastructure.	Very similar to BOOT except that there is no actual ownership transfer. Disadvantages of DBFO include difficulty with long term relationships and the threat of possible future political change where the new leadership may not feel itself bound by prior commitments. Government has advantage of being the owner of the facility, at the same time avoiding administrative burden of processing direct payments from users (Pakkala, 2002).
6	DBOT (Design–Build–Operate–Transfer)	Similar to DBFO.	Very similar to DBFO but with the asset being transferred to government after contractual period. Good example of DBOT is Worli-Haji Ali Sea Link in Mumbai, India.[63,64]
7	DCMF (Design–Construct–Manage–Finance)	Private entity contracted to design, construct, manage, and finance a facility, based on the specifications of the government. Project cash flows result from the government's payment for the rent of the facility.	Examples of DCMF model include prisons and public hospitals.

Table 6: Various PPP Approaches

[63] http://www.indianexpress.com/news/Work-on-Worli-Haji-Ali-sea-link-to-begin-April-1/745784/ (accessed 10 July 2013).
[64] http://www.dnaindia.com/mumbai/1402669/report-worli-haji-ali-sea-link-will-be-ready-in-4-years (accessed 10 July 2013).

3.14 A PPP for HKPF Indoor Radio Communications

In this section we examine whether any of the foregoing models would be suitable for HKPF and, if not, how might the Force move forward.

Earlier in this project report, we discussed and agreed that some form of public-private collaboration is the way ahead for improving police indoor radio communications. Before we take this discussion further, it would be as well to review the objectives of the exercise. These include:

- The improvement of indoor radio communications to a standard equalling or surpassing that achieved by mobile phone operators, this currently being the *de facto* standard in the HKSAR
- The avoidance of significant capital and recurrent expenditure, ergo sharing existing services where possible
- Value for money (a subjective judgement but nevertheless important)
- The utilisation of existing infrastructure where possible
- A low level of risk in the project
- The promotion of public goodwill towards both HKPF and the private sector, and
- An acceptable rate of return in both financial and public relations terms for the private sector

3.15 Finance Options

Against this background, Table 7 reviews the advantages and disadvantages of the various PPP models:

	Model	Advantages	Disadvantages	Suitability for HKPF Indoor Communications Project
1	BOT (Build-Operate-Transfer)	Private sector assumes some risk up to 'Transfer'	1. 'Transfer' not required 2. No 'Lease' 3. Concession agreement required 4. Some public	Unsuitable

			risk	
2	BOOT (Build-Own-Operate Transfer)	Private sector assumes some risk up to 'Transfer'	1. 'Transfer' not require 2. No 'Lease' 3. Concession agreement required 4. Some public risk	Unsuitable
3	BOO (Build-Own-Operate)	Private sector assumes some risk	1. No 'Lease' 2. Concession agreement required 3. Some public risk	Unsuitable
4	BLT (Build-Lease-Transfer)	Private sector assumes some risk up to 'Transfer'	1. 'Transfer' not required 2. Concession agreement required 3. Some public risk	Unsuitable
5	DBFO (Design-Build-Finance-Operate)	Private sector assumes risk	1. No 'Lease'	Unsuitable
6	DBOT (Design-Build-Operate-Transfer)	Private sector assumes some risk up to 'Transfer'	1. No 'Lease' 2. Concession agreement required 3. Some public risk	Unsuitable
7	DCMF (Design-Construct-Manage-Finance)	Private sector assumes some risk	1. No 'Lease'	Unsuitable

Table 7: Financing Options

(Source: Candidate)

As Buttarazzi (2013) presciently observes and as the foregoing review of the literature has suggested, when we consider PPP models we tend to envision large infrastructure projects involving construction, investment and risk. The idea that PPP also has a part to play in service delivery by the emergency services has yet to be entirely embraced.

It will be seen by the analysis at Table 7 that none of the models really satisfy the stated objectives inherent in improving indoor communications and for a number of reasons:

1. It is not desired that the private sector embark upon large-scale infrastructure development, i.e. there is no 'building' involved,[65] ergo no concession agreement is required
2. It is not desired that significant public capital and recurrent expenditure be involved
3. It is desired to share (on a fee-paying basis) existing services and infrastructure assuming such is technically possible, and
4. The sharing of existing services and infrastructure will reduce HKPF risk to the minimum[66]

[65] The mobile phone operator did of course have to 'build' the infrastructure in the first place but it was not part of a PPP. In the future, this may quite conceivably be the case.

[66] The reader will quite possibly come to the conclusion that HKPF is seeking 'something for nothing.' Whilst this may be broadly true, it may also be said that such public-private collaboration – 'sharing' is probably a better word – is long overdue. Competition and the free market, of course, have brought about the state of affairs whereby the private sector competes, but in the private sector the concept of joint ventures, consortiums and the like has been around for a considerable time. The model advanced in this project report simply extends that concept to the public sector.

3.16 Finance-Own-Operate-Share (FOOS)

In bringing HKPF airwaves into buildings, the Candidate has looked for a telecommunications infrastructure in Hong Kong with extensive coverage inside buildings, which is suitable for accommodating the wave band of HKPF CC3 radio service. Owners of such infrastructure are convinced to share their infrastructure without jeopardizing their existing mobile services to the community, and to provide use of their infrastructure to the HKPF by charging an affordable fee.

Section 3.15 depicts no current model, worldwide, entirely fulfils the stated objectives of an HKPF PPP indoor communications project. Accordingly, the reader is introduced to the Candidate's concept of the 'Finance-Own-Operate-Share' PPP Model (FOOS), which has the following characteristics:

1. The private sector finances the building of the infrastructure with no concession agreement involved
2. The private sector owns the infrastructure in perpetuity
3. The private sector operates the infrastructure and services, and
4. The private sector shares its infrastructure with HKPF on a fee-paying basis

So far as can be ascertained from a comprehensive scan of the literature, this is a new application of the PPP concept. The FOOS PPP model will be further explained as the project report progresses.

CHAPTER 4: RESEARCH METHODOLOGY AND METHODS

By three methods we may learn wisdom: First, by reflection, which is noblest; Second, by imitation, which is easiest; and third by experience, which is the bitterest.

CONFUCIUS[67]

4.1 Introduction

Methodology can properly refer to the theoretical analysis of the methods appropriate to a field of study or to the body of methods and principles particular to a branch of knowledge. In this sense, one may speak, for example, of 'objections to the methodology of a geographic survey' (that is, objections dealing with the appropriateness of the methods used) or of the 'methodology of modern cognitive psychology' (that is, the principles and practices that underlie research in the field). People may have taken to this practice by influence of the adjective methodological to mean "pertaining to methods." Methodological may have acquired this meaning because people had already been using the more ordinary adjective methodical to mean "orderly, systematic."

Accordingly, this chapter describes the underlying methodology adopted for the project and a description of the actual methods employed.

[67] Confucius (551-479 B.C.) The Analects of Confucius, in *Chambers Dictionary of Quotations* (1997), Chambers Harrap Publishers, London, p.297.

4.2 Theoretical Framework

A theoretical framework is a logically structured representation of the concepts, variables and relationships involved in a scientific study with the purpose of clearly identifying what will be explored, examined, measured or described (Desjardins, 2010).[68]

It might be argued that a 'straightforward' subject such as improving indoor communications does not require the pedantic exercise of encapsulating it in a theoretical framework. *Au contraire*, a theoretical framework is an essential first step in considering the methodology; in other words how we get from the independent variables – the technical and finance models that we will utilise – to the dependent variable – effective indoor communications.

What concepts are we considering in improving communications inside buildings? Fundamentally, these might be (a) a technical model, and (2) the funding of the implementation of the model. How might these concepts be represented in a theoretical framework figure for the very real world problem of internal communications?

[68] Desjardins, F. J. (2010), *Theoretical Framework*, http://www.youtube.com/watch?v=EcnufgQzMjc (accessed 11 July 2013).

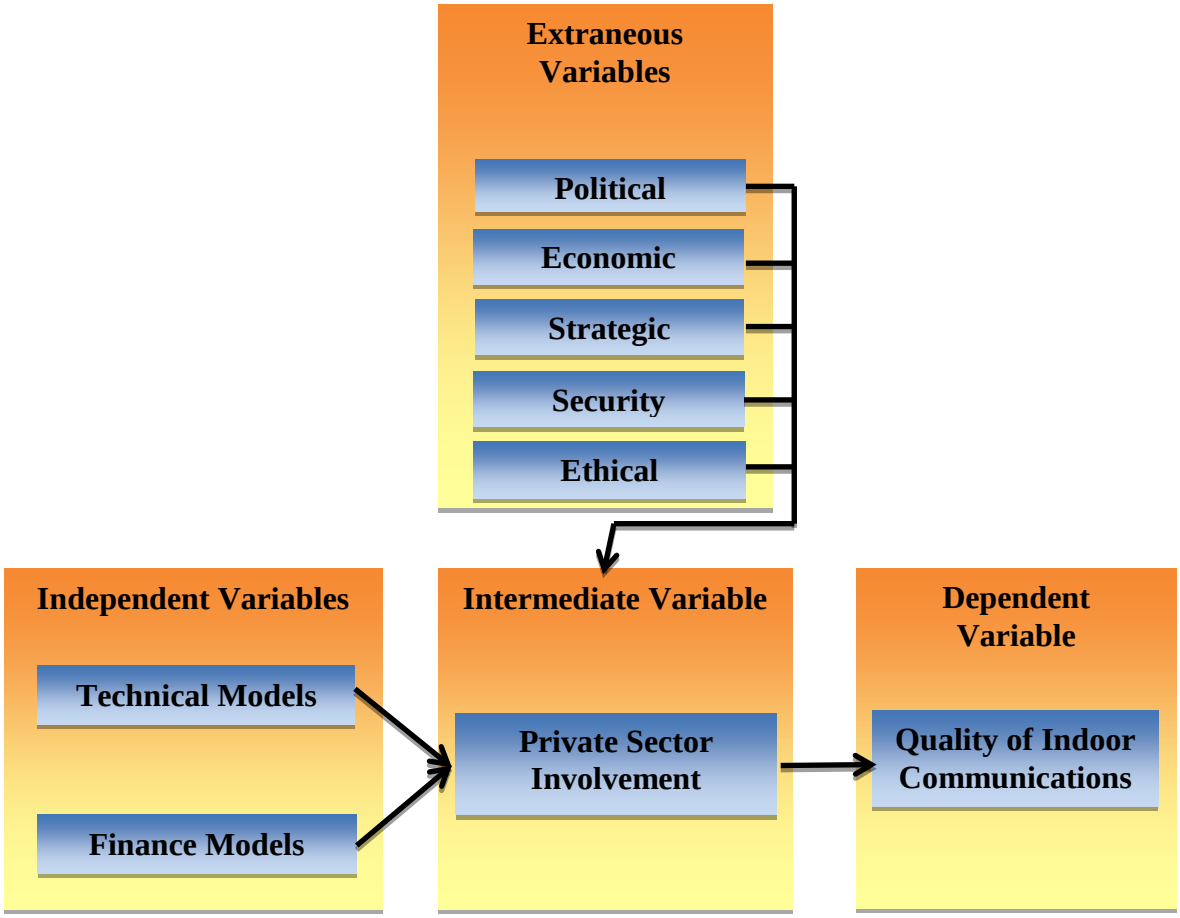

Figure 5: Theoretical Framework for the Improvement Project
(Source: Candidate)

Let us examine these one by one.

4.2.1 Technical Model

Although not a central element of this project report, the theoretical framework must necessarily take account of the fundamental aspects of the technical model. The two principal questions to be asked are (1) are there technical models for improving radio communications in confined spaces, and (2) other than building a (very) expensive, dedicated infrastructure for these models, are there cheaper, effective alternatives? The literature review suggests that the answer to both these questions is 'yes' (Molkdar, 1991; Holmdel, Rustako and Roman, 1987).

4.2.2 Finance Model

The key issue here is: How will the technical model be financed?

4.2.3 Private Sector Involvement

Private sector involvement has been given the status of an intermediate variable as although it is not an independent variable, i.e. not a given, involvement of the private sector or otherwise will have an important bearing on the outcome of the project. Bearing in mind the extraneous factors, private sector involvement may or not be a critical success factor.

4.2.4 Political Factors

The political environment is a fact of life, particularly in government affairs. To secure funding, HKPF will have to take its case to the Government and then the Finance Committee; an organ of the Legislative Council. The proposed model will have to be politically acceptable.

4.2.5 Economic Factors

Is the model affordable? Alternatively, does it constitute value for money? Is it cost effective?

4.2.6 Strategic Factors

Will the model meet users', i.e. front line officers' requirements? Indirectly, will it meet public requirements?

4.2.7 Security Factors

Will security issues be adequately addressed? HKPF communications are currently secure. Will the extension of communications inside buildings compromise this?

4.2.8 Ethical Factors

When conducting research in an academic setting, the Candidate needs to be aware of all ethical issues behind the research activities and actions. As an insider researcher holding a senior position in the workplace and with strong linking to the industry, the Candidate has to be cautious of the ethical factors of applied research and the role as an interested participant. The Candidate may find ethical issue of criticality at some stages during the research activities. Given the generous support by the employer organisation, it takes courageous integrity for the Candidate to criticize colleagues or even bosses. With long-lasting relationship with the industry, including vendors, it is challenging for the Candidate to criticize industry colleagues of their incompetence or lack of creativity. On all these issues of criticality, the Candidate chooses to become a critical friend of the organisation and the industry, through the research findings and results by taking critical analysis and careful review of current knowledge under the work practice. The Candidate can therefore act as an change agent in the workplace and the bluelight industry by promoting new knowledge.

As professional engineer and senior civil servant, the Candidate tightly follows both professional and ethical codes of conduct. The Candidate believes firmly that the nature of the entire research has not touched on sensitive elements, controversial issues or classified information, which may cause physical, emotional or economic harm to subjects of any organisations or individuals.

The ethical mindedness of proper permission, informed consent and unbiased opinion are essential considerations in this project work. Formal invitations were sent by the Candidate to industry stakeholders informing the purpose, nature, scope and details of the research study, leaving them absolute freedom to decide whether they would like to participate in the questionnaires or to provide testimonials. These participants were assured that the entire research would be carried out in a professional manner, to safeguard confidentiality and achieve fairness. In addition, scientific approach to interpret and analyse data were adopted to ensure personal biases and opinions would not get in the way of the research. Individuals who provided the testimonials were telecommunications / emergency services experts, or prominent leaders. They are in a position to provide broad opinions from public (police and telecom regulator), private (industry, telecom operator), and other sectors (academic and

industry associations). With high professional standing they give honest and impartial feedback.

Since HKPF is one of the most visible and scrutinized public organizations in the HKSAR, the Candidate also challenges the limits by asking: will the finance model invite suggestions of unethical practices by HKPF such as collusion between government and business? Will there be conflicts of interest? Are there transparency and equity concerns? These issues will be of particular relevance to any model which involves collaboration with the private sector. In the interests of public good, all five operators were invited to submit a proposal. Through open and transparent tender competitions under WTO regulations, there were neither inequities nor unethical concerns at all.

4.2.9 Quality of Indoor Communications

This is the ultimate dependent variable; the output. The primary success of the project will be judged by the improvement in HKPF indoor communications. It will be necessary to set a yardstick for success. It will be hard to argue a success factor which does not at least match the level of mobile phone coverage inside buildings.

4.3 Project Statement

To recap, the following project statement has been formulated:

> *The development and implementation of a solution to significantly improve police indoor communications by partnering with the private sector, will be a win for both parties; enhanced quality of police service on the one hand, and an important contribution to public service by the private sector, on the other.*

4.4 Project report Questions

In turn and drawing also on the theoretical framework, the Candidate has assembled the following list of project research questions which must underpin the methodology:

1. In improving indoor HKPF communications is there a viable alternative to the traditional approach of HKPF developing its own dedicated telecommunications infrastructure?
2. Will the alternative improve indoor communications to a level attained by the mobile phone operators, which has become the *de facto* standard in the HKSAR?
3. Will the alterative be cost less than the traditional HKPF approach, as above? and
4. Having regard to the theoretical framework, what are the implications of the alternative solution and can they be satisfactorily addressed?

4.5 Methodology

Methodology is the systematic, theoretical analysis of the methods applied to a field of study, or the theoretical analysis of the body of methods and principles associated with a branch of knowledge. It, typically, encompasses concepts such as paradigm, theoretical model, phases and quantitative or qualitative techniques.[69]

A methodology does not set out to provide solutions but offers the theoretical underpinning for understanding which method, set of methods or so called 'best practices' can be applied to a specific case.

It has also been defined as follows:

1. "the analysis of the principles of methods, rules, and postulates employed by a discipline"[70]
2. "the systematic study of methods that are, can be, or have been applied within a discipline,"[71] and
3. "the study or description of methods"[72]

[69] Irny, S.I. and Rose, A.A. (2005), Designing a Strategic Information Systems Planning Methodology for Malaysian Institutes of Higher Learning (isp- ipta), *Issues in Information Systems*, Volume VI, No. 1, 2005.
[70] http://www.merriam-webster.com/dictionary/methodology (accessed 24 July 2013).
[71] Ibid.
[72] Baskerville, R. (2009), Computers & Security, in *Computer and Information Security Handbook*, (Vacca, J.R. ed.), Elsevier Science., **10** (8): 605.

Many recent uses of the word methodology mistakenly treat it as a synonym for method or body of methods. Doing this shifts it away from its true epistemological meaning and reduces it to being the procedure itself, the set of tools or the instruments that should have been its outcome. A methodology is the design process for carrying out research or the development of a procedure and is not in itself an instrument for doing those things. Using it as a synonym for method or set of methods, leads to misinterpretation and undermines the proper analysis that should go into designing research. The use of pre-packaged, 'ready-to-go' methods do not constitute a methodology and are no substitute for the necessary scientific search for the most appropriate method to approach a problem.[73]

In theoretical work, the development of paradigms satisfies most or all of the criteria for methodology. A paradigm, like an algorithm, is a constructive framework, meaning that the so-called construction is a logical, rather than a physical, array of connected elements.[74]

4.6 Methodology Adopted for the Improvement Project

With the foregoing in mind, the Candidate has reviewed the literature for a straightforward, logical methodology to underpin his project of developing a solution for improving HKPF indoor radio communications. He considers that Figure 6 constitutes a workmanlike framework for his methods:

[73] http://www.thefreedictionary.com/methodology (accessed 24 July 2013).
[74] See, for example, Thomas Kuhn, *The Structure of Scientific Revolutions* (University of Chicago, 1970, 2nd ed.).

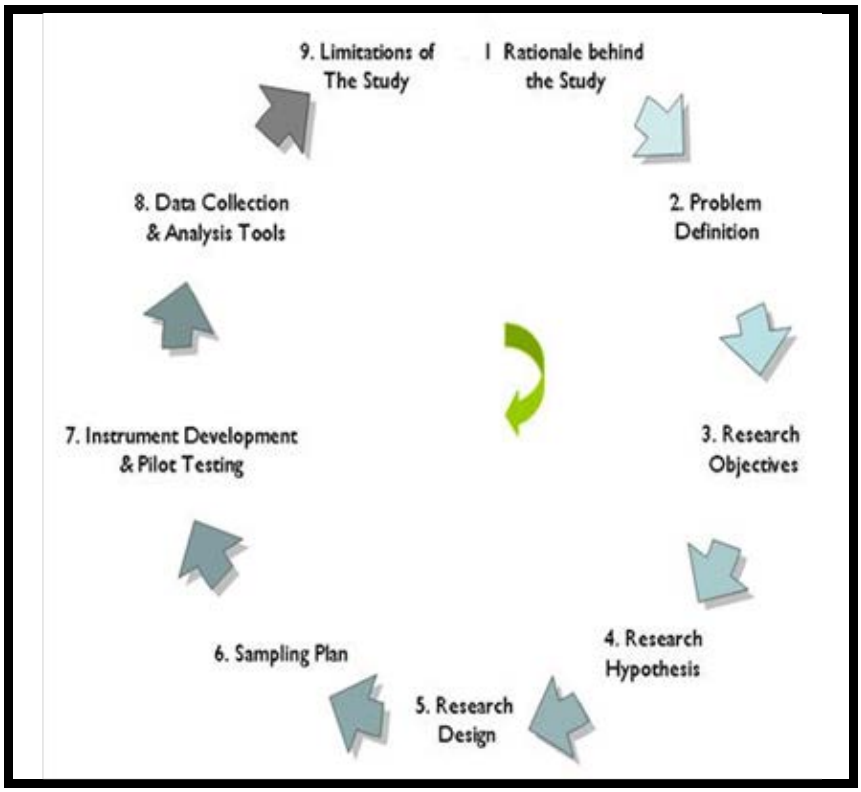

Figure 6: Research Methodology, Rajesh Timane[75]

Note that the model at Figure 6 makes considerable use of the term research whereas in this project report the Candidate has studiously avoided it (to the extent of referring to himself as 'the Candidate' rather than the traditional, 'the researcher'). The Candidate has a problem with describing this endeavour as a research project, in the generally accepted sense of the term. True, the literature review has involved 'research' but beyond the identification of a possibly suitable PPP model, the work over the last several years has been more in the nature of problem solving. We are not treading new ground, in the traditional sense, here. The technical solution, i.e. the carriage of different signals over a common infrastructure, has been with us for quite some time. The liberating aspect of this project, hopefully, has been for the Candidate to posit and more importantly, demonstrate that the operational challenges of working with the private sector to produce an effective, nay cost-effective, model can be achieved. The sacred cow that has been the HKSARG's traditional approach to funding projects (and which, it must be stated, has served the HKSAR well for many years) has been shown to have viable alternatives. Whether the development of this reference model can be labelled 'research' is moot.

[75] http://www.rajeshtimane.com/473/research/research-methodology.html (accessed 5 January 2014).

In keeping with this line of thought, it will be seen that the Candidate has also preferred, where appropriate, the use of the term project rather than project report. Over several years, the Candidate directed a project aimed at improving indoor communications. The project report describes the work done.

Let us now review the methodology, as above and in so doing define the remaining work, i.e. the methods to be accomplished (or, more accurately, identify the outstanding matters to be described in this project report).

4.6.1 Rationale Behind the Improvement Project

The overarching objective of the project is to develop an effective and affordable solution for HKPF to bring its airwaves into buildings

4.6.2 Problem Definition

Fundamentally, the project may be defined as follows:

1. Review and decide upon a technical solution. Pilot it in the first instance
2. Review and decide upon a model for financing the technical solution. Validate it as necessary and assess its political acceptability, and
3. Construct a reference model for the project to be extended to other buildings and in the longer term, adopted, quite possibly in a modified form, in other jurisdictions

4.6.3 Project Statement

A Project Statement has been included in Chapter 2: Terms of Reference. It is reproduced hereunder for ease of reference:

> *The development and implementation of a solution to significantly improve police indoor communications by*

partnering with the private sector, will be a win for both parties; enhanced quality of police service on the one hand, and an important contribution to public service by the private sector, on the other.

4.6.4 Project Hypothesis

The project has no hypothesis as such, other than the straightforward assertion that an effective, cost-effective and politically acceptable solution can be found for improving indoor communications.

4.6.5 Project Design

The general design of the project has been described in Chapter 2: Terms of Reference. It is reproduced hereunder for ease of reference:

1. Review of the business case for improving police communications inside buildings in the HKSAR
2. Review of technical models adopted in other parts of the world and their relevancy to HKPF and the HKSAR
3. Review of finance models to fund the pilot
4. Conduct a pilot of the proposed technical model at one location in the HKSAR
5. Assess the results of the pilot, and
6. Decide upon a finance model to fund the extending of the technical solution to other selected locations in the HKSAR

4.6.6 Sampling Plan

No sampling, as such, will be required in this project.

4.6.7 Instrument Development and Pilot Testing

To test the feasibility of the end-to-end solution covering both technical and financing, a pilot scheme involving private operators will be carried out. Amongst the 60 strategic loctions identified by HKPF, Telford Plaza[76] was chosen for the following reasons:

1. It is the largest shopping and entertainment complex in East Kowloon Region
2. There are some 560,000 residents in East Kowloon
3. There are some 20,000 residents in the adjoining Telford Gardens
4. Telford Plaza is next to the Kowloon Bay MTR (Mass Transit Railway) Station through which some 150,000 commuters pass on a daily basis, and
5. Telford Plaza is a 'neutral' site having no commercial connection with any mobile phone operators in the HKSAR

A full list of the 60 strategic locations is shown in Appendix C.

4.6.8 Data Collection and Analysis Tools

Technical data will be gathered using a the standard approach. The results will be validated by triangulation using: (1) technical data and user feedback; (2) questionnaire feedback from industry practitioners; and (3) testimonials from experts and leading figures in the communications field. Essentially, the technical data and user feedback provide operational justification for the project, and the second and third triangulants provide strategic and political justification, respectively.

Triangulation

In the social sciences, triangulation is often used to indicate that two (or more) methods are used in a study in order to check the results. "The concept of triangulation is borrowed from navigational and land surveying techniques that determine a single point in space with the

[76] Telford Plaza I, recently substantially renovated, is one the largest shopping centres in Kowloon Bay. Telford Plaza II was a more recent addition to Telford Plaza I and their exits face each other. Telford Plaza I has two levels while Telford Plaza II has four. The complex includes shops, banks, restaurants, a cinema, a department store, electronics chain stores, etc. The open-air area has banks, a kindergarten, a community centre, music and dance centres, part of the teaching facilities under City University of Hong Kong, and clinics; http://www.telford-plaza.com/eng/index.asp (accessed 24 July 2013).

convergence of measurements taken from two other distinct points."[77] The idea is that one can be more confident with a result if different methods lead to the same result.

Triangulation is a powerful technique that facilitates validation of data through cross verification from two or more sources. In particular, it refers to the application and combination of several research methodologies in the study of the same phenomenon:[78]

1. It can be employed in both quantitative (validation) and qualitative (inquiry) studies
2. It is a method-appropriate strategy of founding the credibility of qualitative analyses
3. It becomes an alternative to traditional criteria like reliability and validity, and
4. It is a favoured line in the social sciences

By combining multiple observers, theories, methods, and empirical materials, researchers can hope to overcome the weakness or intrinsic biases and the problems that come from single method, single-observer and single-theory studies.

4.6.8.1 Technical Data and User Feedback

The full set of technical data collected from the radio field strength tests is presented in Appendix D. The data shows objectively that the level of radio signal strength was well above the minimum threshold specification (of -95dBm) throughout the test routes. Frontline beat patrol officers were interviewed to confirm their radio services had been satisfactory. In summary, clear voice communication was achieved inside the Telford Plaza between police officers and to their control centre. Concerning security, End-to-end Encryption (E2EE) and Air-interface Encryption (AIE) were being applied to ensure the integrity of the radio services, whereby E2EE and AIE are security mechanisms under TETRA to deal with threats over-the-air and between end-to-end terminals. It is certain that the quality of the police radio service is not compromised by the PPP approach.

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[77] Rothbauer, P. (2008), Triangulation, In Given, L. (Ed.), *The SAGE Encyclopedia of Qualitative Research Methods*, Sage Publications, pp. 892-894.
[78] Bogdan, R. C. and Biklen, S. K. (2006), *Qualitative research in education: An introduction to theory and methods*, Allyn and Bacon.

4.6.8.2 Questionnaire

The Candidate acknowledges that the questionnaire had a technical orientation as it was felt, initially, that (a) the project's core objective was to validate a technical solution to the problem of effective indoor communications, and (b) that respondents would be more comfortable addressing project implementation issues. As the project report progressed, the Candidate realised that important as the technical solution is, the real value of his work lay in devising and implementing a practical way of financing the project, and ultimately producing a reference model. There are a number of technical options and these have been around for some time. The stumbling block, however, for many public safety agencies has been to secure funding for the chosen option. Nevertheless, the questionnaire exercise is considered to have provided important information and validation for the project as a whole and, as such, constitutes a justifiable part of the triangulation process.[79]

Based on a literature review of the optimum methods of constructing a meaningful questionnaire, the Candidate constructed one such to assess industry practititoner views of the project (Foddy, 1994; Gillham, 2008; Leung, 2001; Mellenburgh, 2008; Munn and Drever, 2004; Oppenheim, 2000). A copy of the Questionnaire is at Appendix E. Questions were adapted from prior research work by Li (2003) and Cheung (2009).

The target population (of industry practitioners) comprised relevant attendees at three TETRA events between 2011 and 2012.[80] The total population of these three gatherings was about 1,000 persons, comprising practitioners, policy makers and engineers in the public safety and PPP fields. Only persons expressing an interest to partake in the survey were given a questionnaire and all were returned, i.e. a response rate of 100 per cent. Having regard to the required margin of error of five per cent and confidence interval of 95 per cent, it was calculated that an optimum sample size of 278 was required, i.e. approximately one quarter of the population. Time constraints and other factors made this impractical and a 10

[79] In the event, the questionnaire comprised 13 questions, as follows:
Q1-Q.4. Responder background information
Q5. Rationale behind PPP
Q.6-Q.11. Technical
Q.12. Advantages of using PPP
Q.13. Technical

[80] International TETRA Awards Ceremony in London, 2012; TETRA World Congresses in Budapest and Dubai in 2011 and 2012 respectively.

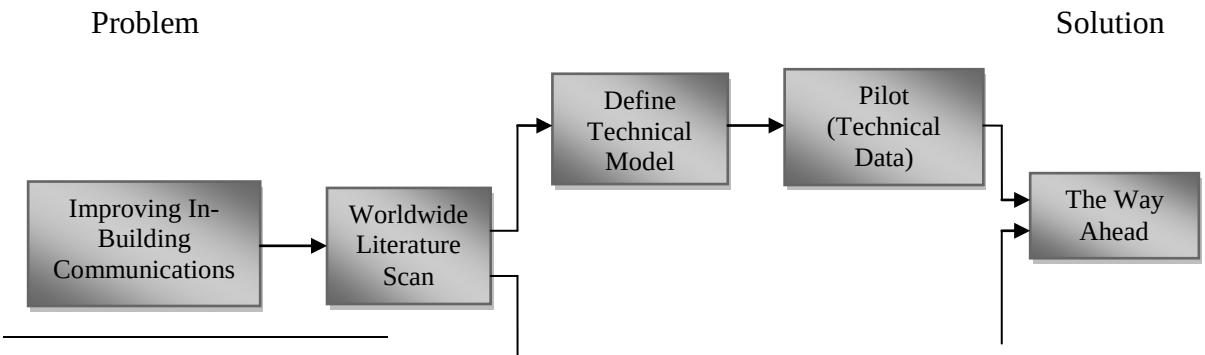
per cent sample was decided upon. In the event, 120 questionnaires were distributed.[81,82] The questionnaire was inter-rated amongst a small group of practitioners for its intelligibility in order to ensure that answers would be appropriately consistent, i.e. that there would not be excessive outriders – excessive outriders would suggest that the questions had not been satisfactorily understood. The choice of TETRA events was to ensure that the responders had an adequate level of expertise in this area.

In the report, One-way ANOVA test was applied for data analysis. Same as statistical techniques like cross-tabulation and chi square tests, it identifies the significant difference in responses from groups of respondents. One-way ANOVA permits a more in-depth understanding of the different views among the groups, through Least Significant Difference (LSD) post-hoc test to show the pair-wise comparison.

4.6.8.3 Testimonials

A total of 14 prominent leaders in the telecommunications industry were approached and invited to provide dispassionate testimonials as to the efficacy of the project, particularly the finance model adopted. Face-to-face interviews with these individuals was impractical hence the decision to solicit written testimonials. This aspect of the triangulation exercise was adjudged important as, at the end of the day, the technical viability of the project will count for nothing if funding to implement it cannot be secured. Many important projects have fallen by the wayside for this very reason.[83]

In line with the methodology adopted, the overall process for the project may be represented diagrammatically thus:



[81] http://blog.questionpro.com/2009/09/25/survey-sample-sizes-how-many-respondents-do-you-really-need/ (accessed 24 July 2013).
[82] http://www.surveymonkey.com/mp/sample-size/ (accessed 24 July 2013).
[83] Peter Halliday, Former Assistance Commissioner of the Hong Kong Police Force; personal communication.

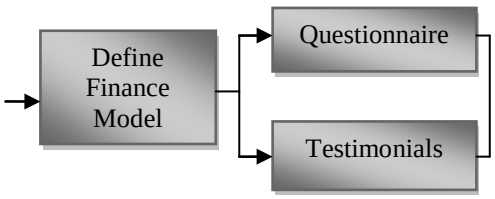


Figure 7: The Project Process

(Source: Candidate)

4.6.9 Limitations of the Study

These will be identified and reviewed in Chapter 7.

CHAPTER 5: DATA INTERPRETATION AND ANALYSIS

> *Governments like to begin things – to declare grand new programs and causes. But good beginnings are not the measure of success. What matters in the end is completion. Performance. Results.*
>
> GEORGE W. BUSH[84]

5.1 Introduction

This chapter addresses the following:

1. An overview of the technical results of the pilot scheme at Telford Plaza
2. User feedback from frontline officers
3. The FOOS finance model adopted
4. Feedback from partners
5. Results of the questionnaire survey of industry practitioners, and
6. An overview of the testimonials from prominent individuals in the telecommunications sphere

5.2 Technical Overview

The pilot scheme was conducted at Telford Plaza between July 2008 and August 2009. Telford Plazas I and II cover some 640,000 square feet of floor space.

The solution adopted was to take the CC3 signal from the HKPF hilltop base station at Mount Parker on Hong Kong Island and inject it into one of the mobile phone operator's indoor networks at Telford Plaza via bi-directional amplifier and fibre-optic cable. The map at Figure 8 shows the geography between the base station and test site:

[84] http://georgewbush-whitehouse.archives.gov/government/fbci/qr4.html (accessed 24 January 2014).

Figure 8: Map of the HKSAR Showing Mount Parker and Telford Plaza (Scale 1: 200,000)
(Source: Government Lands Office)

Field Test Data

Field test data concern themselves with the radio signal strength, i.e. the perceived level of sound volume. That is, whether loud and clear audio communication could take / had taken place.

Measuring Radio Signal Field Strength

The radio signal field strengths were measured prior to, and after, the installation of the technical solution. The data provide objective evidence as to the capability of audio communication utilising CC3 within Telford Plaza. They also served as a regression test on the performance of the existing mobile phone operator's indoor networks, Integrated Radio

Network (IRN), to ensure that radio signal for use other than CC3 would not be degraded after the network migration work.

Test Procedures

1. Before commencement of modification work, the radio signal field strengths of the mobile systems (GSM, PCS and 3G) at Telford Plaza were measured and recorded. The CC3 signal was well below the threshold[85]
2. The measurements were taken in test routes and test point locations appear at Appendix F
3. The CC3 signal from the hilltop base station was injected via bi-directional amplifier (BDA) and fibre-optic cable (Figure 2)
4. After modification of the IRN and migration to CC3, the radio signal field strength measurement for the mobile systems (GSM, PCS and 3G) using the same test routes and test point locations as at item 2 was repeated. This constituted a regression test to ensure that no performance degradation was reported on existing mobile systems other than CC3, and
5. The CC3 radio signal field strength was then measured. This was to confirm that CC3 performance meets design specifications and that audio communications are satisfactory

Test Results

The detailed test results are at Appendix D. The pilot was, technically, a success, with signal strength on a par with that provided by the mobile phone operators.

5.3 User Acceptance Test (UAT) and Feedback from Frontline Officers

Upon the completion of the engineering work, frontline officers were invited to take part in the User Acceptance Test (UAT) by using their beat radios within Telford Plaza I and II, to

[85] After injecting the CC3 signal into the infrastructure, (CC3) signal strength was measured to verify that it was sufficiently high enough to be received by beat radios. The signal threshold is set at -95dBm (signal strength value); any signal strength below this value indicates a good level of reception.

ensure that the service delivered fully meets operational needs. The UAT and-post implementation end-user satisfaction survey results were entirely positive.

5.4 Finance-Own-Operate-Share (FOOS) Finance Model

There are five mobile phone operators in the HKSAR. The estimated contract amount for the pilot at Telford Plaza (less than HK$1 million) meant that under HKSARG tender procedures, an open tender was not necessary. Nevertheless, in the interests of public relations all five operators were invited to submit a proposal.

The contract for the pilot was awarded to SmarTone[86] at a contract price of HK$500,000. Rental and electricity charges were waived by Telford Plaza (which is owned by the Mass Transit Railway Corporation - MTRC) for what the Corporation stated was an additional commitment to corporate social responsibility. The contract was to supply a FOOS solution; that is to say SmarTone was contracted to share its mobile phone network to facilitate indoor CC3 communications.

5.5 Financial Aspects

The pilot was commissioned by SmarTone with collaboration from MTR's maintenance contractor, through a competitive tendering at an affordable cost. Compared with the conventional approach, i.e. an in-house solution designed and funded by HKPF, the capital cost saving was slightly over 50 per cent and the implementation timeline was shortened by three months. A paper describing the pilot scheme was presented at the Hong Kong Institution of Engineers Information and Communications Technology Conference 2010 and appears at Appendix T.

5.6 Extending the Project to Other Strategic Locations.

Following the success of the pilot, an open tender was issued for the same solution to be implemented at 58 other locations. In view of the projected contract price, an open tender was required. Subsequently, contracts were awarded in 2009 to the lowest bids per respective

[86] http://www.smartone.com/jsp/english/index.jsp?dl=1 (accessed 29 July 2013).

sites from either PCCW, CSL or SmarTone.[87] The HKSAR International Airport project was a separate exercise with the contract being awarded to PCCW.

The above contracts comprised 12-month warranty plus 9-year service conditions, including electricity, removal and modification charges. For Telford Plaza, the common antenna network is owned by the landlord, i.e. MTRC. Sharing of this with HKPF is provided free of charge with no time limit. For other locations, landlords either provide their networks free of charge or with a two to three year time limit, whereupon the contract concerned must be renewed. Generally, all contracts will expire in 2019, in line with the development of HKPF's next (4th Generation) command and control communications system, CC4.

5.7 Feedback from Partners

All private sector partners endorsed the PPP model as a 'win' for them and for the community at large. By reusing and sharing existing common indoor radio infrastructure, the PPP model allows fast and environmentally friendly implementation of indoor radio communications for public safety. Costs, resources and disruption have been reduced. A testimonial by the Chief Technology Officer from SmarTone appears at Appendix Q.

5.8 Questionnaire

As stated, a questionnaire survey was conducted amongst industry practitioners. A copy of the Questionnaire is at Appendix E.

The questionnaire responses were evaluated from a number of standpoints to ascertain whether the responses from a particular group of respondents were different from the average or neutral points of the Likert scale. The four standpoints are:

1. Public sector vs. private sector vs. others
2. Responder work experience level
3. Country in which the responder's organisation is based, and
4. Previous involvement in PPPs

[87] These are HKSAR mobile phone operators.

Table 8 shows the master raw descriptive results of the survey for questions 5-13. Questions 1 to 4 were background data regarding the respondents and are therefore not included in the analysis.

Using a 5-point Likert scale, a score of 1 represents Least Important, Very Low Potential or Strongly Disagree, whereas a score of 5 represents Most Important, Very High Potential or Strongly Agree.

Questions	1	2	3	4	5	Total	Mean Score[88]
Q5a	0	4	15	22	7	48	3.67
Q5b	1	6	12	19	10	48	3.65
Q5c	0	6	12	19	15	52	3.83
Q5d	3	13	20	10	2	48	2.9
Q5e	0	3	15	20	7	45	3.69
Q5f	2	4	31	8	2	47	3.09
Q5g	0	4	12	21	12	49	3.84
Q5h	1	3	24	13	2	43	3.28
Q5i	0	6	14	19	5	44	3.52
Q6a	0	2	11	24	14	51	3.98
Q6b	0	4	11	22	14	51	3.90
Q6c	0	5	18	21	5	49	3.53
Q6d	0	9	17	21	4	51	3.39
Q6e	1	12	19	16	3	51	3.16
Q6f	1	14	18	12	6	51	3.16
Q6g	2	2	23	16	8	51	3.51
Q7a	0	2	11	23	17	53	4.04
Q7b	0	5	26	14	6	51	3.41
Q7c	0	4	13	20	16	53	3.91
Q7d	1	4	25	18	5	53	3.42
Q7e	0	2	14	27	10	53	3.85
Q8a	0	1	18	18	14	51	3.88
Q8b	0	0	9	30	13	52	4.08
Q8c	0	1	18	21	12	52	3.85

[88] The mean score is derived from the weighted averages of all the scores for the question concerned. Therefore for Question 5a, for example, the sum of the individual weighted scores is divided by the total score, as follows: [(1 x0) + (2 x 4) + (3 x 15) + (4 x 22) + (5x 7)] ÷ 48, (0 + 8 + 45 + 88 + 35) ÷ 48 = 176 ÷ 48 = 3.67.

Q8d	0	1	21	24	6	52	3.67
Q8e	0	5	15	22	10	52	3.71
Q8f	0	2	10	27	13	52	3.98
Q8g	0	1	20	23	8	52	3.73
Q9a	0	2	17	20	13	52	3.85
Q9b	0	0	11	21	20	52	4.17
Q9c	0	2	19	27	4	52	3.63
Q9d	2	6	20	18	6	52	3.38
Q9e	0	3	12	27	10	52	3.85
Q10a	0	1	12	33	7	53	3.87
Q10b	0	2	13	24	14	53	3.94
Q10c	0	5	18	21	8	52	3.62
Q10d	0	3	18	27	4	52	3.62
Q11	0	0	7	23	22	52	4.29
Q12a	0	4	10	30	8	52	3.81
Q12b	1	2	14	28	7	52	3.73
Q12c	0	1	16	23	12	52	3.88
Q12d	0	1	22	21	8	52	3.69
Q13a	0	1	4	30	18	53	4.23
Q13b	0	3	15	23	12	53	3.83

Table 8: Master Raw Descriptive Results of the Survey (Q5 to Q13).

Using Question 5a as an example, it will be seen that the minimum mean score is 1 [(1 x 48) ÷ 48] and the maximum is 5 [(5 x 48) ÷ 48]. The midline, i.e. the dividing line between [Least Important, Very Low Potential or Strongly Disagree], and [Most Important, Very High Potential or Strongly Agree] is 3. A score greater than 3, therefore, indicates greater agreement, as it were, than disagreement.

Question 5:

Please rate the importance of the following identified reasons for implementing PPP projects:
Under Question 5c, there was a zero response for 1 (Least Important) and 15 responses to 5 (Most Important), whereas the mean score was 3.83. Most respondents consider “Social pressure of poor public facilities” is related to their organisations.
Q5g received a mean score of 3.84 and this suggests that most respondents considered “High quality of service required” is a key reason for implementing a PPP project.

Question 6:

What radio technology options listed below are available for meeting in-building radio coverage and capacity challenges?

The four sub-questions (6a, 6b, 6c, 6g) have mean scores over 3.5. These are consistent with the approach suggested by the FOOS model and also consistent with the view regarding the following radio technology options for meeting in-building radio coverage and capacity challenges - the use of repeaters, bi-directional amplifiers, radiating cable and antenna systems, direct mode gateways and repeaters, and cellular networks.

Question 7:

What are the top three challenges for designing indoor solutions?

The three sub-questions (7a, 7c, and 7e) have mean scores over 3.5. Specifically, the respondents consider the top three challenges for designing indoor solutions are: coverage performance, total cost of ownership, and capacity performance. The PPP model addresses these challenges well in terms of its design specifications.

Question 8:

What are the requirements for designing an optimum indoor network that will smoothly integrate with an outdoor network?

All the seven sub-questions scored above 3.5 and indeed the mean scores are close to 4. Most respondents agree that all the seven requirements for designing an optimum indoor network that will smoothly integrate with an outdoor network are considered essential. These requirements are part of the practical specifications built into the FOOS implementation.

Question 9:

How can you overcome the challenges involved in site acquisition for in-building coverage?

Four out of the five sub questions (Q9a, Q9b, Q9c and Q9e) scored 3.5 or above. Generally, the respondents agreed that to overcome the challenges involved in site acquisition for in-building coverage the following approaches, which were used in the field test of the FOOS reference model, can be used: (1) Keep weight of base station low, size small, and wall mountable; (2) re-use existing indoor radio distribution systems; (3) alternative means of line connection; and (4) keep weight of base station low, size small, and wall mountable. Again these are also built into the design specification of the implementation.

Question 10:

How can you meet building owners' demands for future proofing of in-building solutions?

All the four sub questions received mean scores above 3.5. These results suggested that the respondents agreed that the implementation strategies of supporting standard RF interfaces; adopting wideband cables; supporting the latest IP-over-Ethernet connectivity and ensuring low power efficient consumption, can be used to meet building owners' demands for future proofing of in-building solutions.

Question 11:

Do you consider enterprise femtocells[89] a cost-efficient and convenient alternative to meeting the indoor coverage and capacity needs of emergency services?

The mean score was 4.29. This suggests that most respondents agree that the use of enterprise femtocells is a cost-efficient and convenient alternative to meeting the indoor coverage and capacity needs of emergency services.

Question 12:

Please evaluate the benefits of the following attributes in using the PPP approach to develop in-building radio infrastructure.

All the sub questions received mean scores over 3.5. These suggest that the majority of the respondents concur with the following benefits in using the PPP approach to develop in-building radio infrastructure: fast, simple, low-cost and transparent.

Question 13:

Do you consider it technically and strategically feasible to ride police airwaves over cellular in-building infrastructure?

The two sub questions scored over 3.5. That suggests that the majority of the respondents were of the opinion that it is technically and strategically feasible to ride airwaves over cellular in-building infrastructure.

[89] In telecommunications, a femtocell is a small, low-power cellular base station typically designed for use in a home or small business.

Questionnaire Data Analysis

This section analyses respondent characteristics and attributes (public/private sector; years of experience; HKSAR and overseas, involvement in PPP) in response to Questions 5 to 13.

Comparisons Between Public/Private Sector Responses (re Question 1)

The descriptive results of the aspect of the Questionnaire Survey comparing public-private sector responses to Questions 5 to 13 are presented in Appendix G. The One-Way Analysis of Variance (ANOVA) Test showing whether there are significant differences between groups of respondents to Questions 5 to 13 is presented in Appendix H. If the "sig" column values are less than 0.05, these indicate a statistically significant difference between groups.

Table 9 is a condensed version of Appendix H summarising those questions that show a significant difference among public, private and other respondents:

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Q5a	Between Groups	4.128	2	2.064	3.254	.048
Q5b	Between Groups	8.388	2	4.194	4.650	.015
Q5e	Between Groups	14.883	2	7.441	18.645	.000
Q5g	Between Groups	17.497	2	8.749	17.349	.000
Q7a	Between Groups	6.970	2	3.485	6.018	.005
Q7b	Between Groups	44.629	2	22.314	28.393	.000
Q7c	Between Groups	13.862	2	6.931	11.301	.000
Q8a	Between Groups	7.267	2	3.634	6.223	.004
Q8c	Between Groups	14.666	2	7.333	11.192	.000
Q8e	Between Groups	12.494	2	6.247	11.693	.000
Q8f	Between Groups	14.121	2	7.060	18.344	.000
Q9a	Between Groups	8.246	2	4.123	9.843	.000
Q9c	Between Groups	14.354	2	7.177	17.848	.000
Q9e	Between Groups	8.246	2	4.123	9.843	.000
10a	Between Groups	8.709	2	4.355	11.243	.000
10b	Between Groups	11.633	2	5.817	12.537	.000
10d	Between Groups	9.050	2	4.525	8.778	.001
Q11	Between Groups	2.133	2	1.067	3.594	.035
Q12	Between Groups	14.527	2	7.264	11.982	.000
Q12	Between Groups	8.950	2	4.475	9.002	.000
Q12	Between Groups	7.526	2	3.763	7.829	.001
Q13	Between Groups	6.355	2	3.178	10.643	.000
Q13	Between Groups	18.820	2	9.410	20.771	.000

Table 9: Responses Showing Significant Differences between Public/Private Sectors

For Question 5, the One-Way ANOVA Test suggests there are significant differences among the three groups when rating the importance of the following reasons for implementing a PPP project:

5a. Economic development pressure for more facilities
5b. Political pressure
5e. Shortage of government funding, and
5g. High quality of service required

Similarly, the One-Way ANOVA Test suggests there are significant differences among the three groups in their responses toward questions 7 (a, b, c), Questions 8 (a, c, e, f), Question 9 (a, c, e); Question 10 (a, b, d), Question 11, Question 12 (b, c, d) and Question 13 (a, b).

To permit a more in-depth understanding of the different views among the groups, another statistical technique was used and this is outlined below.

The LSD (Least Significant Difference) post-hoc test shows the pair-wise comparison between two groups, e.g. group 1 vs. group 2; group 1 vs. group 3; and group 2 vs. group 3. In our case, the three groups are public sector (police, fire services, public enterprise and other public safety and law enforcement), private sector (telecom operator, telecom contractor, property management and consultants: engineering, property, finance) and others (education, non-profit organisations and others not included in the above).

The complete comparison is shown in Appendix I. If the "sig" column values are less than 0.05, these indicate a statistically significant difference between the two groups. The condensed version of Appendix I is presented in Table 10 below.

	Between	**Sig**		**Between**	**Sig**
Q5a	(1,3)	0.014		(2,3)	0.042
Q5b	(1,2)	0.010		(2,3)	0.040
Q5c	(1,3)	0.035		(2,3)	0.041
Q5e	(1,2)	0.000		(1,3)	0.000
Q5g	(1,2)	0.000		(1,3)	0.011
Q6a	(1,3)	0.026		(2,3)	0.034
Q6d	(1,3)	0.048		(2,3)	0.036
Q7a	(1,2)	0.005		(1,3)	0.009

Q7b	(1,2)	0.000		(1,3)	0.000
Q7c	(1,2)	0.000		(1,3)	0.000
Q8a	(1,2)	0.000			
Q8c	(1,2)	0.000		(1,3)	0.005
Q8e	(1,2)	0.000			
Q8f	(1,2)	0.000		(2,3)	0.003
Q9a	(1,2)	0.000			
Q9c	(1,2)	0.000			
Q9e	(1,2)	0.000			
Q10a	(1,2)	0.000		(1,3)	0.000
Q10b	(1,3)	0.000		(2,3)	0.000
Q10d	(1,2)	0.001		(1,3)	0.004
Q11	(1,2)	0.011			
Q12a	(1,2)	0.045			
Q12b	(1,2)	0.000		(2,3)	0.007
Q12c	(1,2)	0.000			
Q12d	(1,2)	0.000		(1,3)	0.037
Q13a	(1,2)	0.001		(2,3)	0.000
Q13b	(1,2)	0.000		(2,3)	0.001

Table 10: Multiple Comparisons between Groups of Public and Private Respondents, and Others

Instead of describing all the significant differences, sample examples are used to illustrate the data and results. For example, in Table 10, the entry Q5g indicates significant differences were found among (Group 1 and Group 2); and (Group 2 and Group 3).The significant level is almost zero in (1,2) and 0.011 in (2,3). In these cases, when one reads the descriptive data as presented in Appendix G, it is noted that the Mean score for Q5g ("High quality of service required") by the public sector is 4.52 (close to "most important") but that by the private sector is much lower at 3.29 (close to neutral) and that by the others group is only 3.50.

Question 11:

Do you consider enterprise femtocells a cost-efficient and convenient alternative to meeting the indoor coverage and capacity needs of emergency services?

The table reveals significant differences between, (1,2), Group 1 and Group 2. The average responses from the public sector are on the high end of strongly agree (mean score 4.5) whereas those of the private sector are at the agree level (mean score 4.08)

Question 12:

When asked to evaluate the benefits of the following attributes in using the PPP approach to develop in-building radio infrastructure. (a. fast, b. simple, c. low-cost and d. transparent), all groups, as a whole, agreed. But taking the groups as independent entities, the degree of difference is significant. For example, for Q12a (Fast), the mean response is a clear "agree" but the responses from the public sector (Group code named "1"), fell between neutral and agree.

Question 13:

Do you consider it technically and strategically feasible to ride police airwaves over cellular in-building infrastructure?

The public sector (with mean = 4.45) and the 'others' sector (with mean = 4.83) considered it technically and strategically feasible and strongly agree. The private sector (with a mean= 3.88) was far less enthusiastic and marked it at the 'agree' mark.

Comparisons of Years of Experience (re Question 2)

In this section, the consideration is the effect of respondent years of experience on responses to Question 5 to 13.

The descriptive results of the questionnaire survey for Questions 5 to 13 are presented in Appendix J. The ANOVA (One Way ANOVA Test) showing whether there is a significant difference between groups of respondents to Questions 5 to Question 13 is presented in Appendix K.

Table 11 is a condensed version of Appendix K, summarising those results with significant differences among groups with different years of work experiences.

	Sum of Squares	df	Mean Square	F	Sig.
Q5c Between Groups	21.026	2	10.513	18.128	.000
Q5i Between Groups	4.766	2	2.383	4.036	.025
Q7a Between Groups	9.627	2	4.814	9.152	.000
Q7d Between Groups	11.472	2	5.736	11.292	.000
Q9d Between Groups	6.457	2	3.228	3.780	.030

Table 11: Responses Showing Significant Differences between Groups with Different Years of Experience

The LSD post hoc test shows the pair-wise comparison between two groups, e.g., group 1 vs. group 2; group 1 vs. group 3; and group 2 vs. group 3. Where group 1 refers to respondents with five years or less work experience; group 2 refers to those respondents with 6 to 10 years of experience; group 3 refers those respondents with more than 10 years of experience. The complete comparison is shown in Appendix L. Again, looking at the "sig" column, those figures with values less than or equal to 0.05 indicate a statistical significant difference between the two groups. These are extracted and presented in Table 12 below.

	Between	Sig		Between	Sig
Q5b	(1,3)	0.022			
Q5c	(1,2)	0.010		(1,3)	0.000
Q5i	(1,3)	0.009			
Q6f	(1,3)	0.037			
Q7a	(1,2)	0.021		(1,3)	0.000
Q7d	(1,3)	0.000			
Q7e	(1,3)	0.001		(2,3)	0.009

Table 12: Multiple Comparisons between Groups with Different Years of Experience

For Question 5b, there was a significant difference between group 1 and 3 group respondents. A closer look at the descriptive data in Appendix J shows that the mean response of group 1 is 3.08 whereas that of group 3 is 3.88. What this suggests is that the public sector respondents consider political pressure is natural in the implementation of a PPP but that group 3 (others group) considers a PPP implementation comes with political pressure.

For Question 5c, there were significant differences between group 1 and group 2 as well as between group 1 and group 3. When one compares the means of the three groups of respondents, it was noted that group 1 has a mean of 2.67, group 2 has a mean of 4.25 and group 3 has a mean of 4.17. The significant difference is obvious. In literal terms, those with five years or less work experience consider social pressure regarding poor public facilities is not an important reason for implementing a PPP project. On the other hand the other two groups consider it an important reason.

For question 5i, there was a significant difference between group 1 and group 3 respondents. Group 1 has a mean of 4.09 and group 3 has a mean of 3.34. The significance test suggests

that those with five or less years of experience consider “lack of business and profit generating skill in the public sector” is an important reason for implementing a PPP project, but those with more than 10 years’ work experience are relatively neutral.

For question 6f, there was a significant difference between group 1 and group 3 respondents. Group 1 has a mean of 3.70 and group 3 has a mean of 2.95. The significance test suggests that those with five or less years of experience consider that “WiFi networks” are important but those with more than 10 years of work experience are more ambivalent.

For question 7a, there were significant differences between group 1 and group 2 as well as between group 1 and group 3. When one compares the means of the three groups of respondents, it was noted that group 1 has a mean of 3.25, group 2 has a mean of 4.25 and group 3 has a mean of 4.27. The significant difference is obvious. In literal terms, those with five years or less of work experience consider “Coverage Performance” was not among the top three challenges for designing indoor solutions. However, the other two groups consider it should be among the top three challenges.

For question 7d, there were significant differences between group 1 and group 3. Group 1 has a mean of 2.58, and group 3 has a mean of 3.70. The significant difference is obvious. In literal terms, those with five years or less of work experience considered “New Answer Option” was not one of the top three challenges for designing indoor solutions. However, the group of respondents with more than 10 years of work experience set it among the top three challenges.

For question 7e, there were significant differences between group 1 and group 3, as well as between group 2 and group 3. Group 1 has a mean of 3.17, and group 3 has a mean of 4.16. The mean of group 2 is 3.00. The significant differences are obvious. In literal terms, those in groups 1 and 2 were neutral when asked to vote if “Capacity Performance” was among the top three challenges for an indoor solution but those with 10 years of work experience agreed that it should be among the top three challenges.

Comparison of Country of Origin of Organisation (re Question 3)

As Question 3 has only two groups of respondents (the HKSAR and overseas), a *t*-test was used to compare the difference in responses between the two groups of respondents. "Group Statistics" is included in Appendix M.

The *t*-test results are shown at Appendix N. The column "sig. (two-tailed)" shows whether there is a significant difference in response between the two groups of respondents (shown in the "Independent Samples Test"). A number lower than 0.05 is considered statistically significant and shows a difference in response between the two groups of respondents. Table 13 is a condensed version of Appendix N and shows those questions with significant differences among the two groups (the HKSAR and overseas).

	Sig
Q6b	0.045
Q6c	0.017
Q8a	0.025
Q8g	0.023
Q10b	0.012
Q10d	0.045

Table 13: Responses Showing Significant Differences between Groups with Different Country of Origin of Organisation

Question 6b

What radio technology options listed below are available for meeting in-building radio coverage and capacity challenges? [Radiating cable and antenna systems]

Group 1 has a mean of 3.79 and Group 2 has a mean of 4.44. The respondents from the HKSAR considered "Radiating cable and antenna systems technology" a reasonable technology, whereas those from overseas considered it of much higher potential for meeting in-house radio coverage and capacity challenges.

Question 6c

What radio technology options listed below are available for meeting in-building radio coverage and capacity challenges? [Direct mode gateways and repeaters]

Group 1 has a mean of 3.40 and Group 2 has a mean of 4.11. The respondents from the HKSAR considered "direct mode gateways and repeater technology" a reasonable technology whereas those from overseas considered it of much higher potential for meeting in-house radio coverage and capacity challenges.

Question 8a

What are the requirements for designing an optimum indoor network that will smoothly integrate with an outdoor network? [Ease of use]

Group 1 has a mean of 3.76 and Group 2 has a mean of 4.44. The respondents from the HKSAR considered "ease of use" was a requirement for designing an optimum indoor network that will smoothly integrate with an outdoor network. However, the overseas respondents group showed a much stronger agreement that "ease of use" was an important requirement.

Question 8g

What are the requirements for designing an optimum indoor network that will smoothly integrate with an outdoor network? [Cell preferences]

Group 1 has a mean of 3.84 and Group 2 has a mean of 3.22. While the respondents from the HKSAR tended to agree that "cell preferences" should be requirements for designing an optimum indoor network that will smoothly integrate with an outdoor network, the overseas respondents showed a more neutral stand when presented with such a question.

Question10b

How can you meet building owner's demands for future proofing of in-building solutions? [Adopt Wide Band Cables]

Group 1 has a mean of 3.82 and Group 2 has a mean of 4.56. While the respondents from the HKSAR tended to agree that "Wideband Cables" should be used to meet building owner's demands for future proofing of in-building solutions, the overseas respondents group took a stronger stand in agreeing that "Wideband Cables" can do the job of meeting the future proofing of in-building solutions.

Question10d

How can you meet building owner's demands for future proofing of in-building solutions? [Ensure Low Power Efficient Consumption]

Group 1 has a mean of 3.51 and Group 2 has a mean of 4.11. While the respondents from the HKSAR were lukewarm in agreeing that "Ensure Low Power Efficient Consumption" should be used to meet building owners' demands for future proofing of in-building solutions, the overseas respondents group showed a clear agreement that "Ensure Low Power Efficient Consumption" can meet building owner demands for future proofing of in-building solutions.

Comparisons of PPP involvement (re Question 4)

The ANOVA statistics appear at Appendix O. It will be seen that the respondents' answers are uniform for all questions (Q5 to Q13).

The LSD post hoc test results (Appendix P) reveal no statistically significant difference in the responses between the three groups (those with involvement in PPP, plan to be involved in PPP, and those without involvement in PPP). Note that all groups have mean responses well above 3, indicating that all the groups consider FOOS to be technically sound, and strategically feasible.

5.9 Testimonials

This section summarises and analyses the testimonials of telecommunications and emergency services experts and prominent leaders in a qualitative manner. The testimonial component is the third part of the triangulation exercise. The individuals concerned were invited to contribute based on their leading positions and relevant expertise in the fields of emergency services and wireless communications.

In total, 14 testimonials were received. The testimonials were drawn from the three sectors that were used for the Questionnaire survey: public (police and telecom regulator), private (industry, telecom operator), and others (academic and industry associations). Full details of the testimonials are presented in Appendix Q. A brief summary of the testimonial writers and their affiliations is presented in Table 14.

A. Public Sector	
Name	**Title /Affiliation**
1. Mr. Peter Goulding	Public Safety Specialist, Motorola Solutions Inc. and Former Chief Superintendent, Directorate of Information, London Metropolitan Police, UK
2. Mr. Y K Ha	Deputy Director General (Telecommunications) Office of Communications Authority (OFCA) Hong Kong
3. Dr Peter Halliday	CEO of Elite Consulting Company and Former Assistant Commissioner of the Hong Kong Police Force
4. Mr. François Rancy	Director Radiocommunication Bureau, International Telecommunications Union (ITU)
B. Private Sector (Industry)	
Name	**Title /Affiliation**
5. Dr David Callaghan	Technical Director, Radio Communications Products, Thales UK Ltd.
6. Mr. Stephen Chau	Chief Technology Officer, SmarTone Mobile Communications Ltd., Hong Kong
7. Ir W Y Chu	Senior Telecommunications Manager, CLP Power Company, Hong Kong
8. Mr. Jeppe Jepsen	Chairman, Spectrum Harmonisation, Public Safety Communications Europe and Vice Chairman TETRA and Critical Communications Association
9. Mr. Phil Kidner	CEO of TETRA and Critical Communications Association
10. Mr. Duncan Swan	Partner Analysys Mason Ltd. UK
C. Others (Academic and Industry Associations)	
Name	**Title /Affiliation**
11. Sir David Brown	Chairman of British Standards Institution (BSI) and Past President, The Institution of Engineering and Technology (IET)
12. Professor Martin Henson	Dean for International Affairs, University of Essex, UK
13. Professor Jim Norton	Past President BCS, Chartered Institute for IT and Former Chief Executive, UK Radiocommunications Agency
14. Ms. Sandra Wendelken	Editor Radio Resource International Magazine, USA

Table 14: Individuals Who Provided Testimonials

5.9.1 Testimonials from the Public Sector

The testimonials indicated a need to provide better communication to support emergency services in view of urbanisation and considered the FOOS model proposed in this project report as an innovative approach. Highlights are below.

Demand for Improved Indoor Radio Communications

According to Peter Goulding:

> "It is recognised world-wide by everyone working in the emergency services - people who are dedicated towards the safety of the public they serve - that there is a constant need to have access to effective and consistent radio communications.
>
> Radio communications is not a desirable element of their working tools it is an essential component that enables them to give of their best in the service of others. When radio communications are not available or thwarted by physical or technology barriers, radio users can become less effective; and the consequence can be people who need help and assistance are affected."

Peter Halliday supports this:

> "The height, size and density of buildings in the Hong Kong SAR pose considerable challenges to effective and efficient indoor wireless communication. Whilst it is true that with or two notable exceptions - for example the airport - the police is not responsible for routine law enforcement inside buildings, increasing numbers of commercial premises, notably shopping malls and multi-story car parks, inevitably spawn emergency situations, to which the police must respond.
>
> It is probably true to say that law enforcement agencies, notably the police, have for many years baulked at the notion of extending their telecommunications networks to cover commercial premises, primarily because of the prohibitive capital and recurrent costs involved, coupled with the perceived 'return on investment,' that is to say how often indoor networks will actually be used for emergency communications. The mobile phone companies do not face this dilemma; indeed the use of mobile phones indoors may now well exceed outdoor use and woe betides any mobile phone operator these days who does not provide effective indoor coverage."

Y.K. Ha concurs:

> "Traditionally, radio communications of the Fire Services and the Police Force was provided by radio transceivers installed at vantage points such as hill-top sites, augmented by satellite repeaters installed on roof-tops scattered around the territory. However, this could not be a cost-effective

> arrangement for indoor coverage, particularly for a heavily built- up vertical city such as Hong Kong.
>
> "Against this background, Jolly told me in a discussion sometime after the fire incident[90] that the Hong Kong Fire Services Department had already decided to join the Third Generation Command and Control Communications System (CC3), a state-of-the-art digital radio system established by the Hong Kong Police Force in 2006. In addition, he told me that in the face of the tragic event at the Cornwall Court[91] and similar incidents experienced by police officers while carrying out their duties inside buildings, he had conceived the idea of seeking the assistance of commercial cellular operators to enhance the indoor radio coverage for the law enforcement agencies and the emergency departments. This was a simple yet innovative idea, and I encouraged Jolly to follow up."

There is no doubt in the minds of these commentators that a need exists to improve indoor communications.

The Finance-Own-Operate-Share (FOOS) Model

Peter Goulding again:

> "Mr Jolly Wong, in his research project, highlights one of the key gaps nearly all communities face - the lack of effective in-building radio coverage for their own emergency services. This is one of those solvable problems. The technical solutions exist, are available and are indeed being used in some places. However, the number of active solutions providing in-building coverage into buildings across our cities remains very limited. What this project has highlighted is a practical mechanism that governments, public safety agencies, property developers or owners can adopt; an effective public-private partnership whereby sharing the same

[90] The 1996 Garley building fire was a fire incident that took place on 20 November 1996 in the 16-storey Garley commercial building located at 233-239 Nathan Road, Jordan, Kowloon. It was a catastrophe that caused the loss of 41 lives and 81 injuries. It is considered the worst building fire in Hong Kong during peacetime. The fire damaged the bottom two floors and the top three floors of the building, while the middle floors remained relatively intact. At the subsequent Commission of Enquiry, Fire Services and Police communications were severely criticised as inadequate, including the lack of interoperability.

[91] The (15-storey) Cornwall Court (Nathan Road) Fire was a building fire incident. It began in a nightclub and karaoke bar on the morning of Sunday 10 August 2008, taking the lives of four people, including two firemen, and injuring a further 55 people. At the subsequent inquest the inadequacies of Fire Services Department radio communications were severely criticised. An additional handicap was lack of interoperability with Police communications.

infrastructure placed in buildings can bring shared benefits even when used independently by different parties; the private users and the public safety emergency services. If this partnership proposal was widely adopted then the benefits of providing in-building coverage to the local emergency services could be realised whilst the property developers, building owners and especially the users of these buildings could also gain the additional services and capabilities offered by our essential public safety servants."

Peter Halliday:

"Accordingly, the 'piggy-backing' of emergency communications on mobile 'phone services inside buildings is a notable win-win for both parties, both in terms of efficiency and public relations. Law enforcement has a fundamental stake in the former, whilst a mobile 'phone company stands to significantly enhance its image by offering a public as well as commercial service."

Y.K. Ha:

"I am glad to learn that Jolly has subsequently applied the same arrangement to the Hong Kong International Airport, and he has secured the approval of the top management of the Hong Kong Police Force and the Hong Kong Special Administrative Government to extend the arrangement to another 58 strategic locations. That this PPP model is feasible in Hong Kong is no doubt due to the extremely high penetration of mobile service in Hong Kong, which at 200 per cent of population is recognized by the World Economic Forum Global Information Technology Report 2012 to be the first among the 142 world economies under survey.

I am confident that this model can be applied readily elsewhere, leveraging the infrastructure and the scale economy established by commercial operators. It can be applied not only to the indoor environment (as is the case for Hong Kong), but can also be applied to the outdoor environment in the countryside, or in a closed environment such as an underground railway station or road tunnel. I congratulate Jolly for having conceived such a simple, cost-effective yet extremely powerful model for extending the coverage of government radio communications systems."

François Rancy:

> "I believe that, thanks to this approach, and to the establishment of its feasibility by the work of Ir Jolly Wong, the way is now opened to the establishment of similar networks and partnerships in the World.
>
> Such partnerships will:
>
> – allow the development of public safety networks or high quality and availability
> – at a cost which otherwise would have been out of reach for most countries
> – while saving precious spectrum for other important uses, which otherwise would not have been possible.
>
> In summary, this can be expected to bring to the international community very significant benefits in the future."

The FOOS Model is seen as an option to take police indoor communications forward in an affordable way, and may have international application.

5.9.2 Testimonials from the Private Sector

Testimonials from the private sector have also indicated the need and demand for better indoor communications to support emergency services and consider the FOOS model an innovative approach.

Demand for Improved Indoor Radio Communications

W.Y. Chu:

> "Bringing airwaves into the buildings providing indoor radio coverage has always been a headache for most network operators. It is not only expensive but also difficult to engineer. Traditional way of positioning outdoor base-stations in order to provide sufficient indoor coverage has proved to be ineffective. Thus, setting up indoor repeater stations seems to be the only viable solution. However, it would be costly and not to mention the disruption to the general public during installations."

Jeppe Jepsen:

> "Our emergency services are caught between a rock and a hard place. They need to provide their services everywhere: everywhere is also where communication needs to be; buildings are ever more concentrated and dense and the general public enjoys their communication everywhere they go. Providing coverage everywhere is very expensive, and when you don't have customers willing to pay for that essential service, novel ideas to provide emergency communication everywhere are very welcome."

Duncan Swan:

> "All too often, the operational needs of the emergency services are hampered by their inability to find cost effective solutions to achieving radio coverage, essential for their day-to-day operations protecting and serving the public. The topography and dense urban nature of Hong Kong exacerbate this problem– were the provision of in-building coverage to be left solely to the account of HKPF then finances alone would dictate that there would be significant areas in Hong Kong that would be without reliable, mission critical radio communication. That there is an alternative – and proven – solution that is worthy of consideration in cities across the globe is an excellent outcome to this research."

The Finance-Own-Operate-Share (FOOS) Model

W.Y. Chu:

> "As mobile phone operators would also be facing the same problem, a partnership arrangement would definitely be a smart idea. The Public-Private Partnership (PPP) arrangement will not only achieve the cost effectiveness arena, it would also be more environmental friendly (common infrastructure, less construction works thus less waste generation) and increased speed of deployment. Common infrastructure would definitely have economic gain. However, in order to make it successful, all stakeholders' interests must be addressed. It is not until the equilibrium is reached that the partnership would become stable. Anyhow, this is proved to be successful in Hong Kong where being a good corporate citizen, maintaining good relationship with the government and providing excellent service to its customers matter the most."

Jeppe Jepsen again:

> "Jolly WONG has provided a unique new model to overcome the traditional financial/funding problem and is suggesting a business approach through a public-private partnership (PPP) model to provide that essential radio coverage."

Duncan Swan again:

> "In most forward looking jurisdictions emergency services are primarily provided to serve and protect the community, be that policing, fire & rescue services or emergency health provision. That the emergency services are able to communicate effectively wherever they are required to provide service to the public is essential – and this includes in-building coverage where all of the stakeholders have a beneficial interest. In the UK, where the emergency service radio infrastructure is provided and managed by a commercial entity, government has long suffered from a poor response – both in terms of cost and time – from the commercial provider to implement coverage enhancements to extend coverage beyond contractual requirements…In conclusion, the research of Jolly Wong is to be commended – the next steps are to take this beyond Hong Kong given it has true global application."

In her review of the article, *Hong Kong's Innovative Coverage Model*,[92] Sandra Wendelken, offers the following supporting testimonial regarding the innovativeness of the model:

> "The concept provides an innovative offering for the mobile communications industry to improve public safety and cost savings.
>
> Many public-safety and mission-critical communications entities are exploring public/private partnerships, and your concept specific to in-building radio frequency coverage could be adapted by agencies around the world."

And David Callaghan:

[92] Quarter 1 2012 issue of *Radio Resource International*.

"This is an interesting, innovative and very effective solution to a problem which is being faced, or about to be faced. by public safety organisations around the world. Up to now organisations have commonly enjoyed the benefit of an infrastructure dedicated for public safety use and not shared with consumers or commercial users. In the present economic climate, and as the world is migrating to 4G and beyond in order to satisfy the ever-increasing demands for data, dedicated communications infrastructure is going to present a very big challenge in terms of affordability and sustainability.

The HKP solution has been to 'plug into', at suitable and agreed connection points, commercial telecoms infrastructure and to share the in-building cabling and RF radiating elements inside (for example) shopping malls and stations. (HKP own the spectrum allocation they use.)

This has provided the public safety users with coverage inside difficult locations. But this is only one of the benefits of the approach. Other 'spin-off' benefits include:

1. Reduced public investment
2. Reduced equipment, building and energy consumption
3. Reduced impact on environment (in terms of infrastructure equipment manufacture, support and disposal)
4. Improved public safety service to the general public - enhancing people's security, confidence and well being.

The quest for a solution to in-building coverage has not only solved that particular problem but has also given benefits to the public purse, environment and the general public."

In developing and implementing the pilot solution at Telford Plaza, HKPF partnered with SmarTone Communications. In other words, SmarTone was the 'private' half of the partnership. Accordingly, the thoughts of Stephen Chau of SmarTone are of seminal value and are reproduced in full:

"By reusing and sharing the established common indoor radio infrastructure, the PPP model allows fast and environmentally friendly implementation of radio communications for public safety, requiring lower

> project cost, reduced duplication of resources and less disruption to the landlords. With the collaboration between the public and the private sectors, and their joint contribution in terms of technical skills sets and active involvement in integrating the TETRA system with the existing mobile systems, the PPP model has proven to be a practical and cost-effective approach in extending public safety radio communications in to major buildings….this model… will definitely benefit the Government and the public community."

5.9.3 Key Testimonials from Other Sectors

Extracts from the testimonials by Jim Norton, David Brown and Martin Henson are included below.

Demand for Improved Indoor Radio Communications

Jim Norton commented:

> "Global city centres include a complex mix of major buildings and underground facilities supporting both transportation systems and retail/recreational centres. It is increasingly difficult to provide ubiquitous, reliable, radio coverage and it seems wasteful simply to duplicate multiple infrastructures – even if that could be afforded."

David Brown:

> "The nature of the built environment is evolving at an ever-increasing pace and is presenting radio engineers with an increasingly challenging environment. In no sector is a response to these challenges more urgent than in the 'blue light' services."

The Finance-Own-Operate-Share (FOOS) Model

Jim Norton:

> "I welcome the opportunity to support this genuinely innovative development. …The pioneering Public-private Partnership (PPP) approach,

now clearly demonstrated by the Hong Kong Police Force (HKPF) in both the major transportation hub of Hong Kong International Airport and in the Telford Shopping Plaza, blazes a trail for others to follow.

It is particularly helpful to see HKPF exploring the broader applications of their work beyond the Hong Kong SAR through the questionnaire "How the Police Service is bringing their airwaves into buildings". I very much look forward to the publication of the results of this research and to other police forces around the world building on the Hong Kong examples and sharing their experience."

David Brown:

"His approach is novel because he begins not from a technical standpoint, as might be expected, but by examining business models which have not hitherto been considered, perhaps because they have been assumed not to be viable. His examination has been rigorous, and that rigour has served to convince stakeholders in both the public and private sectors that they should implement the proposed Public-Private Partnership model on two important sites in Hong Kong. The reality has matched the promise, so it is likely that this symbiotic business model will be adopted widely in many parts of the world.

In carrying out this work, Jolly Wong has displayed thought-leadership of an extraordinary degree, in both the technical and commercial arenas, and has generated new knowledge on which he and others can now build to push the boundaries yet further. I have no hesitation in commending his work."

Martin Henson:

"It is extremely impressive that the Hong Kong Police Force adopts such a creative and visionary approach towards public safety and policing in general. However, such a vision would be nothing if not for people like Mr Wong who have the capacity to turn ideas into reality.

We were extremely impressed by the new business model, based on a Public-Private Partnerships concept that brings together the needs, capacities, infrastructure, expertise and interests of all the key stakeholders—leading to a most innovative approach to solving important

> societal and social benefits. It is remarkable and noteworthy that such a broad range of technological, business focused and novel ideas relating these areas is required to deliver positive results such as those he has obtained. No doubt this model can be adapted to many other scenarios- in a commercial context for example. Overall, his work is unique and highly innovative."

In sum, there is strong support from a range of prominent figures in the telecommunications sphere that an effective solution for police indoor communications is needed and that the Candidate's FOOS model is a serious option.

CHAPTER 6: CONCLUSIONS

> *I've seen people spend days, if not months, researching and gathering data, but only at the end did they finally figure out what they were really looking for; then they had to redo a lot of stuff. If after a day or so you force yourself to put together your tentative conclusions, then you'll have guidance for the rest of your research.*
>
> ROBERT POZEN[93]

6.1 Introduction

Chapter 6 reviews the project and its results, and offers thoughts on the way forward for effective indoor communications. Having regard to Pozen's dictum above, the Candidate did not 'supply the answer before asking the question' but certainly set himself the firm objective of devising a solution to the challenge of indoor radio communications.

Trzeciak and Mackay (1994) observe a number of useful 'ingredients' that form part of a conclusion:

- A summary of the main part of the text
- A deduction made on the basis of the main body
- The writer's opinion on what has been discussed
- A statement about the limitations of the work
- A comment about the future based on what has been discussed
- The implications of the work for future research, and
- Important facts and figures not mentioned in the main body,

[93] Pozen, R.C. (2012) *Extreme Productivity: Boost Your Results, Reduce Your Hours*, HarperCollins Publishers, New York, p.21-23.

and likewise make the point that as with introductions it will not always be necessary or desirable to include all the elements they mention.

Pallant (2009), meanwhile, sees the conclusion slightly differently. She argues that the conclusion should "leave (the reader) with a clear impression that the purposes of the essay have been achieved" (Slaght and Pallant, 2012, p.41). Pallant sees five basic ingredients of a conclusion as follows, though these will not always be used in the same conclusion:

- A summary of the main points (being careful not to repeat exactly what has already been written)
- Concluding statements
- Recommendations
- Predictions
- Solutions

On the whole, Trzeciak and Mackay's approach seems workmanlike and logical although it will not be slavishly adhered to in these concluding remarks.

6.2 Innovative Aspects of the Project

Innovation in public sector administration and economics is a world phenomenon. Government authorities are innovating and changing to adapt to a changing world. In undertaking this project, the Candidate focused on one of the key challenges that nearly all communities face - the lack of effective in-building radio coverage for emergency services - and devised the FOOS PPP model to address the common challenge.

FOOS has quickly achieved the operational challenge of extending radio communication support to frontline police officers in the discharge of their duties at the indoor shopping malls in the HKSAR. Operational efficiency and personal safety of frontline officers has been heightened and as such the level of public safety enhanced.

There have been three specific benefits to both Government and community:

1. Private sector resources, expertise and creativity have been exploited

2. The commercial potential of a government-held project (value-added commercial services are normally not government's core-business) has been maximised, and
3. Costs and risks have been transferred and managed in a proper manner, and delivered in a faster timeline and under strict control protocols

The FOOS PPP model won the International TETRA Innovation Award on 27 March 2012 in London. This gives it international credibility.[94]

6.3 Implications for Public Safety

CC3 is a mission critical system for emergency response, which enables the police to respond faster to emergencies. The time saved greatly enhances the chance of saving life, in life and death situations. FOOS has helped to underpin HKPF's Vision of ensuring that the HKSAR remains one of the safest and most stable societies in the world. The successful implementation of the FOOS PPP model (single site FOOS – Telford Plaza; 58 site FOOS with multiple contractors; the HKSAR International Airport[95]) at 60 strategic locations has achieved predicted results. The validity of the FOOS model has been further confirmed via a triangulation of research methods.[96]

In sum, what this project has proposed is a practical mechanism that governments, public safety agencies, property developers and owners can adopt; an effective public-private partnership, whereby sharing the same infrastructure placed in buildings can bring shared benefits even when used independently by a range of different parties; the private users and the public safety emergency services.[97]

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[94] Best TETRA Innovation sponsored by Sepura. Entries:
•Airwave – 'TETRA Messager'
•Alcatel-Lucent and Rohill – 'TETRA over LTE'
•APD Communications - 'Voice Over IP TETRA Port Pooling Solution'
•Axell Wireless – 'Stockholm Metro Project'
•Funk Electronic – 'DVI-100'
•Hong Kong Police Force – 'Business-model Based Innovation'
•Sigma Wireless – 'ComAlerter - TETRA Messaging System'
http://www.tetra-manufacturers.com/item.html&objID=19354 (accessed 1 August 2013).

[95] Police CC3 air waves were officially extended into the Hong Kong International Airport in November 2012.

[96] Wong J. (2012), *Hong Kong's Innovative Coverage Model*

[97] Cullucci, T.A. (Ed.), (2008), *A Guide to the Cost-Effective and Efficient Communication of Needs*, Department of Homeland Security, Washington D.C., at http://www.dhs.gov/xlibrary/assets/Developing_Operational_Requirements_Guides.pdf (accessed 1 January 2014).

The FOOS model is now also being seriously considered by other police services.[98]

A possible next step on the Candidate's part will be to expand the list of critical success factors identified by the literature review, to a full list of factors. This would give FOOS potential worldwide application. For instance, it is extremely important to spell out the key role a FOOS change agent or change enabler, must play. A second consideration will be what kind of attributes this individual will need as a leader to successfully deploy the FOOS model in another part of the world or in non-emergency settings.

6.4 Realisation of Research Objectives and Project Benefits

6.4.1 Research Objectives

The project objective was to develop an innovative and affordable solution for emergency services to effectively bring their airwaves into buildings. The objective was successfully met by the business model based innovation through PPP.

6.4.2 Project Benefits

The project has achieved benefits for the three main stakeholders, as hereunder.

Law Enforcement Agencies (Public): Bringing police airwaves into buildings has facilitated effective communication between patrolling officers, and between patrolling officers and their command and control centres. In-building radio coverage has increased the effectiveness of the policing presence at strategic locations and enhanced officers' personal safety.

Mobile Phone Operators (Private): Mobile phone operators have achieved an additional source of revenue as HKPF will subscribe to their infrastructure and maintenance services. Additionally, this move to 'public service' of behalf of the operators will significantly

[98] At this writing, the Metropolitan Police Service in London and the Singapore Police Force are considering adopting FOOS.

improve their credibility and standing with the public. At the practical level, mobile phone operators' contribution to essential public services will strengthen their case in instances where they wish to extend their services to buildings where there are landlord objections.

Community (People): Members of the public will have a heightened level of trust in HKPF to safeguard and protect life and property.[99] There will also be awareness amongst the thinking people that public money is being spent judiciously.

Overall, the paradigm has moved from a win² ('win-win') situation to a win³ as illustrated in Figure 9 below:

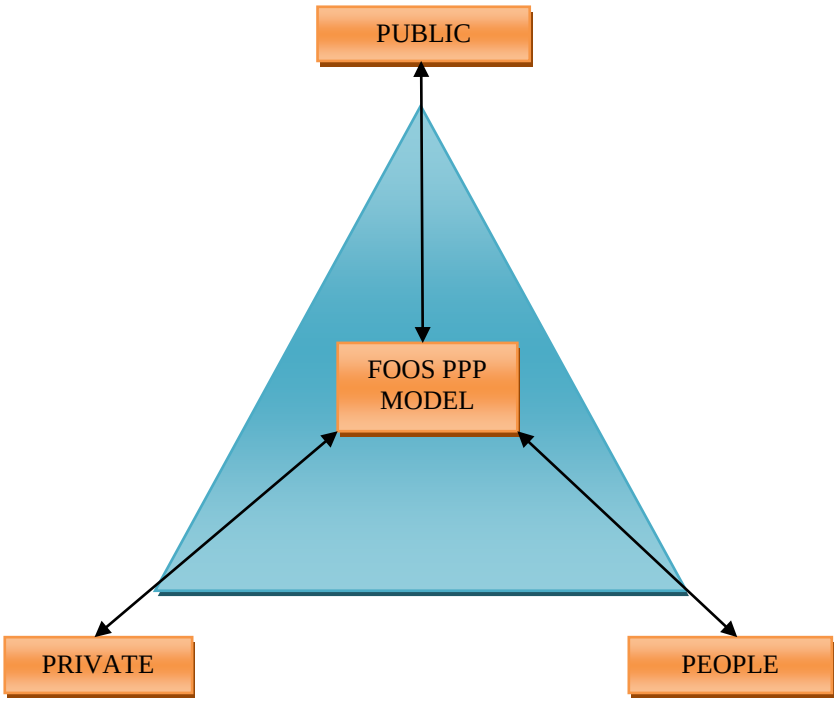

Figure 9: The Win³ PPP Model

[99] It would be as well to remember that they will have heightened expectations as well.

6.5 Recommendations

6.5.1 New Buildings to be Communications-Enabled

The project highlights the need for renewed attention to new building regulations. New buildings exceeding certain sizes and intended for particular uses – and including buildings undergoing extensive renovation – should include the necessary communications infrastructure to support emergency service radio communication. Indeed, new buildings of any significance being constructed today do include the latest information and communications technology (ICT) infrastructure to facilitate access to the outside world. Surely, it is not unduly stretching the imagination to conceptualise such infrastructure supporting the emergency services as well?

HKPF has started preliminary dialogue with the Office of the Communications Authority (OFCA) regarding the concept of 3G licence renewal including a point of interface (POI) for emergency services inside buildings.

6.5.2 Next Generation Emergency Services Mobile Requirements

The public safety industry worldwide is investigating and collating the future requirements of the emergency services for mobile communications. Today there are two separate technology families for providing terrestrial wide-area wireless communications: commercial cellular networks and dedicated public safety radio systems. To provide the best service to both communities there is now industry support for greater use of common technology. Work is underway on Release 12 of 3GPP LTE (3rd Generation Partnering Project: Long Term Evolution) standards which will enhance LTE to meet emergency services application requirements. (Sharp, 2013). There is general consensus on the following four priorities:

1. Group call and other public safety functionality
2. Direct (device to device) mode communications
3. Prioritisation and guaranteed access, and
4. Interoperability

The Candidate is confident that the PPP model will continue to flourish in the public safety sphere. It does not seem unreasonable to assert that in, say, 10 years' time emergency services will be sharing common digital communications technology with the public, including standards and very possibly sharing networks as well (IET, 2012). The likely outcome on this timescale will be the combination of emergency services and private sector capacity in exchange for preferred access to private sector systems whenever needed. Through economies of scale, this will give public and private sectors an expandable chunk of a large pot rather than each having to depend on their small and easily-overloaded pots, and improving resilience into the bargain.

The Candidate is cautiously optimistic that the FOOS Model will be considered for adoption elsewhere, both in the HKSAR and overseas. Nevertheless, the Candidate is equally aware that innovation is generally not exportable lock, stock and barrel. Due allowance must be made for differing political, economic, social and technological – to name a few – factors elsewhere. Nevertheless the Candidate is convinced that a reference model can be produced and – subject to the requisite environmental scanning - adapted as necessary by other jurisdictions. Accordingly he presents Figure 10 which attempts to provide a framework for deciding whether the FOOS approach should be adopted:

#	Issue	Factors	Remarks
1	Socio-Cultural	Social factors include cultural aspects and include health consciousness, population growth rate, age distribution, career attitudes and emphasis on safety. Trends in social factors affect the demand for a *government/company's services/products and how that government/company operates. For example, an aging population may imply a smaller and less-willing workforce (thus increasing the cost of labour). Furthermore, governments/companies may change various management strategies to adapt to these social trends (such as recruiting older workers) Question: Are there any socio-cultural factors militating against the FOOS approach? Question: Does the FOOS approach accord with social and cultural norms (or, perhaps better, does it run counter to social or cultural norms)?	There is probably quite a fine line between 'Socio-Cultural' and 'Politics'
2	Technology	Technological factors include technological aspects such as R&D activity, automation, technology incentives and the rate of technological change. They can determine barriers to entry, minimum efficient production level and influence outsourcing decisions. Furthermore, technological shifts can affect costs, quality, and lead to innovation Question: Is the jurisdiction concerned sufficiently technically advanced to attempt the FOOS approach?	
3	Ethics	Public sector ethics is a set of principles that guides public officials in their service to their constituents, including their decision-making on behalf of their constituents. Fundamental to the concept of public sector ethics is the notion that decisions and actions are based on what best serves the public's interests, as opposed to the official's personal interests (including financial interests) or self-serving political interests Question: Are there ethical issues militating against the FOOS approach?	'Ethics' and 'Socio-Cultural' are sometimes closely intertwined. Ethics vary from place to place. This does not necessarily make one country's ethics 'good' and another's 'bad;' just different
4	Environment	Environmental factors include ecological and environmental aspects such as weather, climate, and climate change, which may especially affect industries such as tourism, farming, and insurance. Furthermore, growing awareness of the potential impacts of climate change is affecting how governments/companies operate and the products they offer, both creating new markets and diminishing or destroying existing ones Question: Can the FOOS approach be argued on environmental grounds?	
5	Politics	Political factors are basically to what degree the government intervenes in the economy. Specifically, political factors include areas such as tax policy, labour law, environmental law, trade restrictions, tariffs, and	

		political stability. Political factors may also include goods and services which a government/company wants to provide or be provided (merit goods) and those that the government/company does not want to be provided (demerit goods or merit bads). Furthermore, governments/companies have great influence on the health, education, and infrastructure of a nation Question: Is the FOOS approach acceptable politically? Question: Can serious political opposition, for whatever reason, be anticipated?	
6	Legal	Legal factors include discrimination law, consumer law, antitrust law, employment law, and health and safety law. These factors can affect how a government/company operates, its costs, and the demand for its services/products Question: Is the FOOS approach lawful in the jurisdiction concerned?	
7	Economy	Economic factors include economic growth, interest rates, exchange rates and the inflation rate. These factors have major impacts on how government/companies operate and make decisions. For example, interest rates affect a company's cost of capital and therefore to what extent it grows and expands. Exchange rates affect the costs of exporting goods and the supply and price of imported goods in an economy Question: Is there funding available? Question: Is there a sufficiently attractive business case for the private sector to participate? Question: What objections are the private sector likely to raise for not participating? Question: What arguments need to be brought to bear to persuade the private sector to participate? Question: Is there sufficient competition in the mobile phone operator market in the jurisdiction concerned to persuade operators that the corporate, i.e. government market, is as important as the mass market?	It is accepted that the private sector will readily appreciate the political capital to be derived from a FOOS project (public relations, for the most part) but the ultimate decision will be made on economic grounds
8	Demography	Demographic factors include gender, age, ethnicity, knowledge of languages, disabilities, mobility, home ownership, employment status, religious belief or practice, and income level Question: Are there any demographic obstacles?	
9	Regulatory	Regulatory factors include acts of parliament and associated regulations, international and national standards, local government by-laws, and mechanisms to monitor and ensure compliance with these Question: Are there bureaucratic hurdles?	
10	Strengths	The characteristics of the project that give it an advantage over others. Question: What are the strong points about the FOOS approach to be argued in the jurisdiction concerned?	
11	Weaknesses	The characteristics of the project that place it at a disadvantage.	It is as well to identify these before some other person or entity surprises you with them. Indeed, it

			can sometimes be advantageous to launch a pre-emptive strike by putting them on the table at the outset
12	Opportunities	Elements that the project can exploit to its advantage	An initiative or innovation is sometimes cynically argued as being an idea that is not going anywhere. The challenge will be to argue the FOOS approach as being a genuine opportunity
13	Threats	Elements in the environment that could cause trouble for the project Question: In this significantly less than perfect world, what dangers lurk out there that could derail a FOOS project?	

*'Government/company' as used in this model should be construed as 'public sector' and 'private sector'

Figure 10: FOOS PPP Reference Model

CHAPTER 7: MAJOR OUTCOMES

You will never understand bureaucracies until you understand that for bureaucrats procedure is everything and outcomes are nothing. If you have been living in a world where outcomes are everything, you may have a very hard time understanding bureaucratic thinking or practices.

THOMAS SOWELL[100]

7.1 Introduction

Chapter 7 discusses the strategic outcomes of the project, either realised or hopefully realisable in the future. Outcomes should be contrasted with outputs which, in contrast, refer to the largely quantifiable work done, and are essentially tactical entities.

7.2 Outcomes of the Project

In his RAL 8, the Candidate attempted to identify the intended outcomes of the project but made the point that a definitive statement of outcomes would not be possible until, most importantly, the completion of the pilot.

Nevertheless, the Candidate's RAL 8 posited the over-arching outcome of a significant improvement in HKPF's discharge of its public safety and law enforcement responsibilities brought about by the implementation of an effective indoor communications solution. Such solution would be realised by answers to the following research questions:

1. What (radio technology) solutions are available for meeting in-building radio coverage and capacity challenges?
2. What are the main challenges to designing indoor solutions?

[100] Right Wing News, *The Best Quotes From The Last 52 Thomas Sowell Columns At Town Hall Starting 3/25/04* at http://www.rightwingnews.com/quotes/the-best-quotes-from-the-last-52-thomas-sowell-columns-at-town-hall-starting-32504-2/ (accessed 24 January 2014).

3. What are the requirements for designing an optimum indoor network that will smoothly integrate with the outdoor network?
4. How can the challenges involved in site acquisition for in-building coverage be overcome?
5. How can building owners' demands for future proof in-building solutions be met?
6. Are enterprise femtocells a cost-efficient and convenient alternative to meeting the indoor coverage and capacity needs of emergency services?
7. How can a fast, simple, cheap and transparent radio infrastructure to realize in-building systems everywhere be developed? and
8. Is it technically and strategically feasible to ride police airwaves over cellular in-building infrastructure? What are the main challenges and obstacles?

All these questions have been comprehensively addressed in the project report. Let us now look at what operational outcomes have been achieved.

In Chapter 2, we tentatively discussed what the outcomes of the indoor communications project might be. At Table 15 is a more definitive list with commentary.

	Outcome	Commentary	Remarks
Short Term Outcomes (Now)			
1	Reduce use of mobile phones	HKPF officers currently make extensive use of mobile phones inside buildings. Mobile phones have a number of limitations including the inability to utilise talk-groups as is the case with TETRA public safety radio. Officer safety with mobile phones is also limited due to the lack of an emergency button, activation of which enables the command and control centre to pinpoint an officer's location quickly and accurately. There will be substantially less need to use mobile phones inside buildings in the future.	Mobile phone cost savings Security enhanced by greater use of the CC3 infrastructure
2	Apprehension of criminals	HKPF has a good record for speedy response to crimes outdoors and subsequent apprehension of criminals. The same cannot be said for responses to crimes indoors, notably because of the lack of coordination of the search effort. Effective indoor communications will improve this situation	Will also contribute to heightened HKPF credibility and approval ratings
3	Efficiency and effectiveness indoors	The current lack of effective indoor communications has a negative impact upon the general efficiency and effectiveness of HKPF operations indoors. Implementation of the FOOS model will mitigate this problem. Indoor activities include dealing with crime scenes, search, cordoning, crowd	

		control and general watch-and-ward	
Intermediate-Term Outcomes (Over the Next Year)			
4	Public satisfaction with HKPF	It can be expected that HKPF's general improvement in efficiency and effectiveness inside buildings brought about by better communications will have a positive effect on public approval ratings. There are a large number of indoor places of public resort in the HKSAR and these are frequented by hundreds of thousands of people on a daily basis	
5	Government and Legislature reaction – reduced costs	The implementation of the FOOS model inside buildings will result in substantial cost savings for the Government (perhaps more accurately expressed as substantial cost avoidance). This can be expected to incur a positive reaction from the Government. Likewise, the Finance Committee (an organ of the Legislative Council) can be expected to applaud the reduced impact on the public purse	
6	Government and Legislature reaction – public-private partnership	Both the Government and the Legislature can be expected to react positively to a government department partnering with the private sector to not only achieve substantial cost avoidance but also make a specific contribution to the public good	Essentially a political outcome but an important one, nevertheless
7	Reduction of crime	One is tempted to forecast that the implementation of the project will see a quick reduction in crime. This is unlikely. Whilst the criminal world is a responsive one, this change in HKPF *modus operandi*, if you will, will take time to 'work its way through the system.' Nevertheless, it can be expected that crime will reduce as criminal elements come to realise that HKPF is now, essentially, as effective indoors as outside	
8	Detection of crime	The primordial role of HKPF, as above, is to prevent crime. If crime, however, cannot be prevented then the public expects a high detection rate and speedy apprehension of criminals ('before they can do it again'). The FOOS model should significantly improve the coordination of searches for fleeing criminals inside buildings	
Long-Term Outcomes (Over the Next Several Years)			
9	HKPF credibility	Whilst the analogy is not precise, it was Montgomery (amongst others) who commented that it is victories, not battles, which win wars, i.e. it is results that count. It is to be hoped that the general improvement in HKPF efficiency and effectiveness resulting from this project will see a general improvement in public satisfaction with the police. Whilst this improvement may be as much perception as reality, experience shows that perception is often a more powerful force and represents facts in the minds of many	Media's major contribution, good or bad, to society: shaping public perception
10	HKPF-public relations	Public relations (PR) is the practice of managing the spread of information between	

		an individual or an organisation and the public (Grunig and Hunt, 1984). The general aim of (HKPF)-public relations is to persuade the public, partners, employees, and other stakeholders to maintain a certain (positive) point of view about it, its leadership, activities and accomplishments, and its political decisions (Rubel, 2007). It can be anticipated that heightened efficiency and effectiveness on the part of HKPF at indoor places of public resort will enhance PR.	
11	HKPF international reputation	With crime becoming increasingly transnational and law enforcement becoming increasingly a worldwide family of agencies, HKPF's international reputation is most important. That reputation is built by the perception, internationally, that HKPF is competent and professional. Implementation of the FOOS model will contribute to this in a not insignificant way.	
12	Respect for HKPF by the Government and Legislature	Whilst, as above, HKPF's efforts at cost avoidance will garner kudos, it is to be hoped that in the longer term, the innovation manifested by the FOOS project will contribute to the overall respect in which HKPF is held by the Government and the Legislature	It is vital that HKPF is 'taken seriously' by the Government and the Legislature. One result of this, logically, should be a sympathetic (or, at least, interested) ear being lent to HKPF submissions for resources
13	Catalytic effect	It is to be hoped that the project will act as a catalyst for a similar approach being adopted, as appropriate, to other HKPF initiatives, indeed to initiatives by other government departments	
14	Catalytic effect – international	Interest in the project being shown by the Metropolitan Police Service in London and by the Singapore Police Force is an example of how FOOS may enhance HKPF's international reputation	A paper "A new win-win-win business service model for the Hong Kong Police Force" was published in the International Journal Services and Standards, Vol.8, No.1, August 2012 pp 24-44 (A copy is at Appendix S)
15	Changes to building regulations	A number of countries now mandate that new buildings should be 'communications-ready' in that communications infrastructure should be included in the construction. It is to be hoped that the project spurs a review of this issue in the HKSAR	

Table 15: Outcomes of the Research Project

Let us also apply the New Zealand Treasury's three-fold test described in Chapter 3 to these outcomes. It will be recalled that this test comprised:

1. "Is the public agency able to specify outcomes in service level terms, thereby leaving scope for the PPP consortium to innovate and optimize?
2. Is it easy for the public agency to specify outcomes in a way that performance can be measured objectively and rewards and sanctions applied?
3. Are the public agency's desired outcomes likely to be durable, given the length of the contract?"

The Candidate contends that in terms of the indoor communications project, the answer in each case, is 'Yes.' This gives added validity to adopting a PPP approach.

7.3 Personal Outcomes for the Candidate

The Candidate lists hereunder his personal achievements as a result of the success of the project:

- Won the 1st Runner-Up Hong Kong Police Force Service Quality Award 2010 in appreciation of the commitment to continuous improvement in the pursuit of service excellence through the pilot scheme in Telford Plaza (Appendix R);
- Received the HKPF Commissioner Commendation for professionalism, devotion to duty, commitment, initiative and teamwork of an exceptionally high order displayed between 2010 and 2013 in appreciation of the enhancement of CC3 radio coverage into indoor locations (Appendix R);
- Clinched the Best TETRA Innovation Award from the Inaugural International TETRA Awards 2012 organized by the TETRA and Critical Communications Association (TCCA) and TETRA TODAY Magazine on 16th March 2012 at Savoy Hotel, London (Appendix R).
- Published the project experiences in the following international journal and book chapter:
  i. Wong, J., Kwok, P. and Tsang, P. (2012), *'A New Win-win-win business service model for the Hong Kong Police Force'*, International Journal Services and Standards, Vol. 8, No.1, pp 24-44' (Appendix S)

ii. Wong, J., Tsang, P., Man, K. and Pang, K. (2011), '*The Development of CC3 for a speedier response for public safety and healthcare*', Emergency Services and Healthcare Informatics 2.0. HK: City University Press, pp298-303

- Presented the project experiences in the following international conferences and seminars:
  i. Wong, J. (2010), '*A novel approach to extend police radio waves into buildings – making Hong Kong a safer city'*, The HKIE ICT Conference, Hong Kong 2010Wong, J. (2011), '*A new public-private partnership model'* The IET International Communications Conference on Wireless Mobile & Computing (CCWMC) 2011, Shanghai 2011 (Appendix T)
  ii. Wong, J., Kwan, R. and Tsang, P. (2011), '*A new public-private partnership business model'*, Technology Information & Innovation Management (TIIM) Conference 2011, Finland 2011
  iii. Wong, J. (2012), '*Hong Kong's Innovative Coverage Model: How public safety extends signals inside buildings'*, Radio Resource International, pp.26-33

7.4 Project Limitations

Limitations here refer not to shortcomings, which are discussed in Chapter 8, but to factors or circumstances which had a constraining effect upon the project. Another way of putting this might be to ask if there were factors that prevented the project from truly addressing its objectives.

In this view, the development and implementation of the project had no limitations. A technical solution was devised; the pilot was funded; a partner was identified; the pilot was a success; and the solution is now being extended to other sites.

It is in the extending of the solution to other sites that a constraint of sorts might be advanced, although whether it amounts to a constraint is moot. The indoor communications solution has been or is being extended to a further 59 sites in the HKSAR over and above the pilot site at Telford Plaza. But that will still leave a large number of sites uncovered. True, the other 59 sites were selected for good reason as being sites that in competition with the 'unlucky ones' are locations where there is a good business case for indoor coverage. But the completion of

the project, i.e. indoor coverage at 60 selected strategic sites, will still leave CC3 coverage markedly inferior to the coverage of the mobile phone networks. About the only place that mobile phone coverage fails these days is inside lifts or kindred enclosed spaces.

This brings us to the future ideal; all-encompassing CC3 coverage in- and outdoors, and such is discussed in Chapter 8.

CHAPTER 8: REFLECTIONS

Life must be lived forwards, but it can only be understood backwards.

Adapted from SØREN KIERKEGAARD[101]

8.1 Introduction

This final chapter reflects upon the project report.

Human self-reflection is the capacity of humans to exercise introspection and the willingness to learn more about their fundamental nature, purpose and essence. The earliest historical records demonstrate the great interest which humanity has had in itself. Human self-reflection invariably leads to inquiry into the human condition and the essence of humankind as a whole (Kemmis, 1985).

As a professional engineer by training and practice for over thirty years, it seemed to the Candidate that the traditional Ph.D. degree would not necessarily satisfy his strong desire to apply diverse knowledge and concepts in practice. He drew inspiration from the concept of a forward-thinking approach by applying practice-based professional research in the workspace to solve a real-life problem. The Candidate also wanted to challenge and question conventional thinking by investigating a solution for one of the most serious problems faced by the public safety sector.

8.2 Beginnings[102]

At this point, nearing the end of a long trail, it is appropriate to reflect upon the project and on what was done well, and what could have been done better. In the poet William Wordsworth's words: "Habit rules the unreflecting herd."[103] It is so easy to keep doing what

[101] https://www.goodreads.com/author/quotes/6172.S_ren_Kierkegaard?page=1 (accessed 24 January 2014).
[102] The statements in this section regarding CC2 and CC3 are drawn from the Candidate's personal experience as Head of HKPF's Communications Branch.
[103] http://www.bartleby.com/145/ww629.html (accessed 5 August 2013).

we have always been doing. Introspection and moreover the open-mindedness to concede that things can be done better are, it must be conceded, difficult traits of the human condition. But we spurn vision and innovation at our peril. Planet Earth is a finite entity with finite resources. The human race is probably the only one not threatened with extinction and grows every day.[104] How will humanity continue to sustain itself in the face of dwindling resources?

The development of HKPF's CC3 was certainly a bold attempt at visionary development. For a start, it involved a migration to completely new technology. Fundamentally, CC3 is a low-power, digital, UHF TETRA-based radio system, to provide wide area fast call setup "all informed" group calls. Furthermore, the low power specification and use of roof top repeaters permit extensive radio spectrum re-use around the infrastructure. It is most suitable to satisfy the needs of emergency services in a high density city like Hong Kong.

By contrast, CC3's predecessor, CC2, was a significantly higher powered VHF analogue system with hill top repeaters and as such its air waves achieved significant penetration into buildings. It was used extensively for point-to-point communications. As such, CC2 supported remarkably effective indoor communications.

Whilst CC3, therefore, embraced new technology and, in totality, took HKPF forward in terms of the efficiency and effectiveness of its radio communications, it must be said that it exacerbated the challenges of indoor communications. In this view, HKPF brought some of the current problems with indoor communications upon itself. Indeed, the specification for CC3 in the tender document made it clear that communication beyond one metre inside buildings was not expected.

Hindsight is a wonderful thing but there is no doubting that the potential exacerbation of indoor communications problems caused by the commissioning of CC3 could have, at the very least, been assessed more comprehensively in the development of CC3, than in fact it was.

[104] By about 204,000 people a day; CIA World Factbooks, 2005-2006.

Nevertheless, whether a more incisive approach would have resulted in substantial design modifications, is doubtful. The reader will have noted that the on-going programme to bring HKPF airwaves indoors is only targeting a total of selected 60 buildings, including the HKSAR International Airport. The Airport project was, of course, a 'no-brainer;' a great deal of police activity takes place within the (vast) terminal buildings and effective communications thereat are mission-critical. It is probable that a modified CC3 design would also have contented itself – on cost grounds alone - with providing communication to selected buildings.

The technical solution adopted for the indoor communications project has been to 'plug in' CC3 to mobile phone operator infrastructure at each of the 60 locations. This more incremental approach was probably practical and realistic. There remain, however, a large number of indoor places of public resort still uncovered by HKPF radio.

The project has given the Candidate an opportunity to reflect on the wider issue. Future generations of HKPF command and control must address the increasing indispensability of all-encompassing communications, in- and outdoors.

Rather than plugging in at individual locations, it seems sensible to start exploring a total sharing of mobile phone operator infrastructure by plugging in at one – or a limited number – of core points. The technical challenges remain to be assessed but if communications can be said to be almost definitely moving in at least one direction, that direction is surely the concept of joining hands in terms of infrastructure and spectrum, instead of the 'everyone for themselves' which has been (probably inevitably) the paradigm for the last century.

8.3 Partnering

The Candidate does not claim the sharing approach to be entirely novel. Very little – if anything – we do today has not at least been thought of down the ages. Telephone and even electricity cables have been used to transmit multiple radio waves simultaneously for some considerable time. The Candidate does however submit that a government agency sharing an infrastructure with a private enterprise represents a move forward in public-private cooperation, and a cooperation, moreover, demonstrably in the public interest. It is to the great credit of the mobile phone operators in the HKSAR that when this concept was floated

those years ago, there was almost immediate interest and enthusiasm. Naturally, the prospect of additional revenue was attractive but the Candidate has no recollection, during the tendering process and subsequent contract negotiations, of this having been the private sector's raison d'être; quite the reverse, in fact. The mobile phone operators all displayed a keen sense of mission and public spiritedness.

This sharing of infrastructure, of course, has been rather more than a case of simply 'plugging in' CC3 to the mobile phone operator's network. The CC3 infrastructure comprises a combination of a microwave network core coupled with some 120 low power base stations. These cannot be simply plugged in and a considerable amount of front-end work was necessary to establish the various linkages. As has been seen, this work was expensive, but markedly cheaper than HKPF simply extending its own infrastructure inside the selected buildings. These considerations give further justification to the concept of a complete merger of HKPF and mobile phone operator infrastructure in the future.

And there is a further consideration: Supporting radio communications is not part of police core business. HKPF is in the business of law enforcement. True, there has probably been little alternative to current arrangements, i.e. a dedicated HKPF infrastructure, over the years, but times and priorities change. The Candidate is under no allusions as to the potential political obstacles of such an integrated approach in the future and it is likely that attempts will be made to play the 'security card' as well. Any such complete merging will have to take account of the fact that HKPF communications are mission-critical. Reliability and redundancy issues will have to be considered. The mobile phone operators will have to become <u>true</u> government partners sharing a common mission and values.

8.4 The Project Itself

The Candidate has critically reflected on his approach to the project; again, oh that hindsight could become foresight! The conceptualisation was sound. The deciding of the technical solution, the decision to approach the private sector and the tendering process, all went relatively smoothly.

In the cruel light of day, the industry questionnaire and the gathering of testimonials should have been more tightly focussed. The development of the Questionnaire took, essentially,

technical issues as its baseline and even some of these questions, on reflection, were either somewhat shallow or rhetorical. It was not until further down the road with the project that the Candidate came to a realisation (not a blinding one, but something of an epiphany, nevertheless) that the centre of gravity needed to be moved; away from the technical aspects of the project, and more towards the relatively liberating aspect which was to engage the private sector. This engagement was not the traditional approach of tendering for a contractor to develop and implement a solution, but a genuine partnering, not only in the commercial sense, but in the philosophical one as well.

Likewise, the gathering of testimonials should have been more focussed. A number of prominent figures were essentially asked: "What do you think of the project?" A more incisive question would have been: "How might the project have been improved?"

8.5 Writing

The actual writing of the project report went through a number of iterations, again to do with deciding what exactly the core of the project was. It is not too whimsical to recall Churchill's words:

> "Writing a book is an adventure
> To begin with it is a toy
> Then an amusement
> Then it becomes a mistress
> Then it becomes a master
> And then it becomes a tyrant
> And the last phase is…
> That just as you are about to become reconciled to your servitude
> You kill the monster."[105]

Perhaps the steepest part of the writing learning curve for the Candidate was deciding upon the level to pitch the project report. The Candidate's background had prepared him for a piece of writing which assumes relevant technical knowledge on the part of the reader. For

[105] Churchill's remarks upon receiving the Nobel Prize for Literature in 1953 for his six-volume work *The Second World War* (http://www.youtube.com/watch?v=2AHlqgHURAo, 3:48, accessed 5 August 2013).

this project report to find appeal, however, it is necessary that it – whilst not treating the reader as a child – explains the whole project clearly, logically and in a manner that, if desired, enables others to replicate the work done.

It is to be hoped that the Candidate has achieved understanding on the part of the reader of the journey that he undertook and on that note the project report ends.

The End

(Total words count: 29,373)